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A. I. & S. E. E. DISTRICT SECTION SECRETARIES

L. O. MORROW

C. H. HUNT

Coming Meetings

CHICAGO DISTRICT SECTION

PHIL SMIDT'S

Wednesday, February 19, 1936—7:30 P.M.

"Interesting Control Applications in Steel Mills" by L. A. Umansky, Industrial Engineering Department of the General Electric Co., Schenectady, New York.

PHILADELPHIA DISTRICT SECTION

ENGINEERS CLUB—1317 SPRUCE ST.

Saturday, February 1, 1936—7:00 P.M.

"Application of Waste Heat Boilers to Gas Engines" by T. A. Lewis, Combustion Engineer, Bethlehem Steel Company, Bethlehem, Penna.

BIRMINGHAM DISTRICT SECTION

THOMAS JEFFERSON HOTEL

Saturday, February 29, 1936—7:00 P.M.

(To be announced later.)

PITTSBURGH DISTRICT SECTION

WILLIAM PENN HOTEL—CARDINAL ROOM

Saturday, February 29, 1936—8:00 P.M.

"Stress Analysis in Locomotives and Other Large Axles" by T. V. Buckwalter, Vice President and Doctor O. J. Horger, Research Engineer, Timken Roller Bearing Company, Canton, Ohio.

SPECIAL FEATURE:—Moving pictures of the continuous hot strip and cold strip mills of the Ford Motor Company, Detroit, Mich., and the continuous strip mill of the Carnegie-Illinois Steel Corp., McDonald, Ohio. These moving pictures will be furnished through the courtesy of the Timken Roller Bearing Co.

CLEVELAND DISTRICT SECTION

(To be announced later.)

ARTHUR J. WHITCOMB

BIRGER THELE

W. W. SPANAGEL

EDITORIAL

THE PLANS of the Association for 1936 will be carried out under very favorable and encouraging circumstances as all branches of its activities are greatly stimulated by the improved business conditions especially as related to the steel industry and builders of mill equipment.

First of the principal items which will receive special attention are the district sections. The five sections—Birmingham, Cleveland, Chicago, Philadelphia and Pittsburgh are well organized and the attendance of these meetings has been satisfactory. With the broad plans of plant improvement that are being programmed by the steel companies for the near future, there will be many subjects to be investigated and discussed which will naturally increase the interest in the section meetings.

Plans are rapidly being formulated for the Spring Engineering Conference to be held under the auspices of the Combustion Engineering Division, in Youngstown, Ohio, on April 22 and 23. This two day session is expected to draw 1000 executives and engineers in the industry.

The thirty second Convention and Iron and Steel Exposition to be held in Detroit, Michigan, September 22, 23, 24 and 25 of this year is of predominant interest to the membership of the A. I. & S. E. E. and the steel industry at large. Already 100 companies have reserved space in the Iron and Steel Exposition which promises to be larger and more representative than any previously conducted. Executives and engineers of the automotive industry are particularly interested in the technical program and are co-operating to make this convention and exposition a success.

As other plans of the Association for 1936 are developed they will be referred to the members for their consideration and cooperation.

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OPEN HEARTH FURNACE OPERATION

FOUR MILLION B. T. U. PER TON

By E. H. SCHWARTZ, Supt. Open Hearth Dept.†
And G. E. ROSE, General Superintendent
Wisconsin Steel Works
SOUTH CHICAGO, ILLINOIS

Paper presented before the A. I. & S. E. E. Convention, Pittsburgh, Pa., September 24, 25, 26, 1935.

G. E. ROSE

E. H. SCHWARTZ

▲ EXPERIMENTS with the use of mixed blast furnace and coke oven gas as an open hearth fuel have been under way at the Wisconsin Steel Works since March, 1928, at which time the first campaign on mixed-gas was begun on No. 1 open-hearth furnace. After a total of four campaigns had been made on this furnace on mixed-gas, and after No. 2 open-hearth furnace had also been rebuilt for mixed-gas and was operating on this fuel, the results obtained were reported in a paper before a meeting of this association at Hamilton, Ontario, five years ago on June 18, 1930. Since then we continued one or two open-hearth furnaces on preheated mixed-gas until forced down by the depression. When business picked up in 1934, giving us sufficient surplus coke oven and blast furnace gas to resume operation on this fuel in the open-hearth department, we resumed operation on mixed-gas and now have five open-hearth furnaces, with prospects of more, on regenerated mixed-gas.

In our previous paper we reported the results obtained on three campaigns on mixed-gas, No. 1 furnace, using fixed ports; and one campaign on this same furnace using movable ports. The fuel practices obtained on fixed ports varied from 7,900,000 B.T.U. per gross ton of ingots on the first campaign to 4,989,000 B.T.U. per gross ton on the third campaign. The installation of the movable ports reduced this fuel practice to 4,518,000 B.T.U. per gross ton of ingots. This latter fuel practice was made on a furnace which had already made 382 heats on stationary brick ports, and covers the results obtained on 354 additional heats made with movable ports, or a total of 736 heats without cleaning the checkers. Since then we have built two new furnaces, Nos. 8 and 9, the design of which is a modification of our earlier furnaces as dictated by our experience thus far with mixed-gas.

On these furnaces we enlarged somewhat the volume of the gas checker chambers as compared with the volume of the air checker chambers. We continued the use of the double pass checkers on both the gas and air, and also continued the use of the movable ports. These furnaces, during the past three or four months, have shown the following performance:

†Presentation of this paper was made by F. M. WASHBURN, Asst. Supt. Metallurgy and Inspection, Wisconsin Steel Works, South Chicago, Illinois.

NO. 8 O. H. FURNACE

	June	July	August	7-Mo. Average June-Dec. Inc.
(1) Fuel Practice, B.T.U.	4,077,910	3,765,070	3,936,460	4,212,690
(2) Preheat Temp. in Mixed-gas	2,155°F.	2,177°F.	2,170°F.	2,161°F.
(3) Preheat Temp. in Air	2,052°F.	1,962°F.	1,930°F.	1,863°F.
(4) Avg. Stack Temperature	934°F.	905°F.	892°F.	906°F.
(5) Ratio Bl. Fce. Gas to C.O. Gas	2.54 to 1.00	2.47 to 1.00	2.41 to 1.00	2.52 to 1.00
(6) Number of Heats	58	59	59	385
(7) Ingot Tonnage	7,156 G.T.	7,365 G.T.	7,267 G.T.	47,833 G.T.
(8) Bl. Fce. Gas, 90 BTU; C.O. Gas 582 BTU	.....	.....	.....	.....
(9) % Hot Metal in Charge	34.7%	36.1%	36.5%	35.6%
(10) % Steel Scrap in Charge	65.3%	63.9%	63.5%	64.4%
(11) Avg. Time Per Heat	12 hr. 23 min.	12 hr. 32 min.	12 hr. 38 min.	13 hr. 1 min.
(12) Avg. Size of Heat	123 G.T.	125 G.T.	123 G.T.	124 G.T.

NO. 9 O. H. FURNACE

	June	July	August	7-Mo. Average June-Dec. Inc.
(1) Fuel Practice, B.T.U.	4,315,710	4,151,000	4,127,930	4,296,540
(2) Preheat Temp. in Mixed-gas	2,162°F.	2,149°F.	2,150°F.	2,174°F.
(3) Preheat Temp. in Air	2,022°F.	1,929°F.	1,877°F.	1,821°F.
(4) Avg. Stack Temperature	822°F.	806°F.	812°F.	833°F.
(5) Ratio Bl. Fce. Gas to C.O. Gas	2.55 to 1.00	2.56 to 1.00	2.49 to 1.00	2.54 to 1.00
(6) Number of Heats	57	56	59	382
(7) Ingot Tonnage	7,049 G.T.	6,973 G.T.	7,283 G.T.	47,535 G.T.
(8) Bl. Fce. Gas, 90 BTU; C.O. Gas 582 BTU	.....	.....	.....	.....
(9) % Hot Metal in Charge	34.5%	36.0%	36.9%	36.2%
(10) % Steel Scrap in Charge	65.5%	64.0%	63.1%	63.8%
(11) Avg. Time Per Heat	12 hr. 27 min.	13 hr. 4 min.	12 hr. 44 min.	13 hr. 3 min.
(12) Avg. Size of Heat	124 G.T.	125 G.T.	123 G.T.	124 G.T.

The data given for the seven month period was supplied by the authors in January, 1936, just before going to press.

Our No. 1 open-hearth furnace, back on mixed-gas again, in making alloy and special steels, mostly *with a cold pig charge* and requiring an average of 15 hours and 13 minutes per heat, for 40 per cent of its production, shows the following performance at the present time:

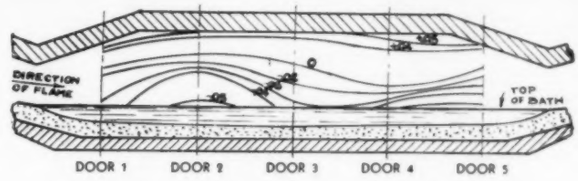
NO. 1 O. H. FURNACE

(1) Fuel Practice, B.T.U.	5,094,430
(2) Preheat Temp. in Mixed-gas	2,023°F.
(3) Preheat Temp. in Air	1,572°F.
(4) Avg. Stack Temperature	950°F.
(5) Ratio of Bl. Fce. Gas to C. O. Gas	2.28 to 1.00
(6) Number of Heats	251
(7) Ingot Tonnage	30,562 G.T.
(8) Bl. Fce. Gas 90 BTU; C.O. Gas 582 BTU	
(9) % Hot Metal or Cold Pig in Charge	38.9%
(10) % Steel Scrap in Charge	61.1%
(11) Avg. Time Per Heat	14 hrs. 9 min.
(12) Avg. Size of Heat	122 G.T.

The other two furnaces on mixed-gas have been swung over from oil firing, but have not as yet had their checkers rebuilt for gas firing.

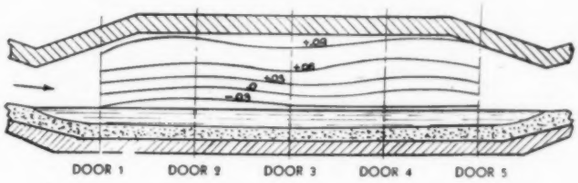
You will note that we have bettered considerably the figure of 4,518,560 B.T.U. per ton of ingots reported in our previous paper for the last campaign on No. 1 O. H. furnace with movable ports. In fact, our No. 8 O. H. furnace is making steel regularly with less than 4,000,000 B.T.U. per gross ton of ingots, and our No. 9 O. H. furnace is running just a little over 4,000,000 for this campaign, but is down to 3,972,720 B.T.U. for the first three weeks of September; or, in other words, is getting better as it gets older.

We feel that the open hearth department offers itself as the most continuous user of surplus gases from the blast furnace and by-product coke departments. In steel plants where by-product coke ovens are adjacent to blast furnace and open hearth departments, there is not only a large excess of coke oven gas from the coke department, but an even larger supply of excess blast furnace gas. An ordinary 100-ton open-hearth furnace requires only 150,000 Cu. Ft. of blast furnace gas *per hour*, and an average sized blast furnace of 700 to 800 tons capacity per day, makes this amount of gas *in less than three minutes*. At many plants the tightening up of blast furnace gas leaks would go a long way in furnishing sufficient blast furnace gas for



NO. 7 O.H. FCE. (OIL FIRED) PRESSURES TAKEN AT ℄ OF FURNACE.

(STATIC PRESSURES GIVEN IN INCHES OF WATER)



NO. 9 O.H. FCE. (GAS FIRED) PRESSURES.

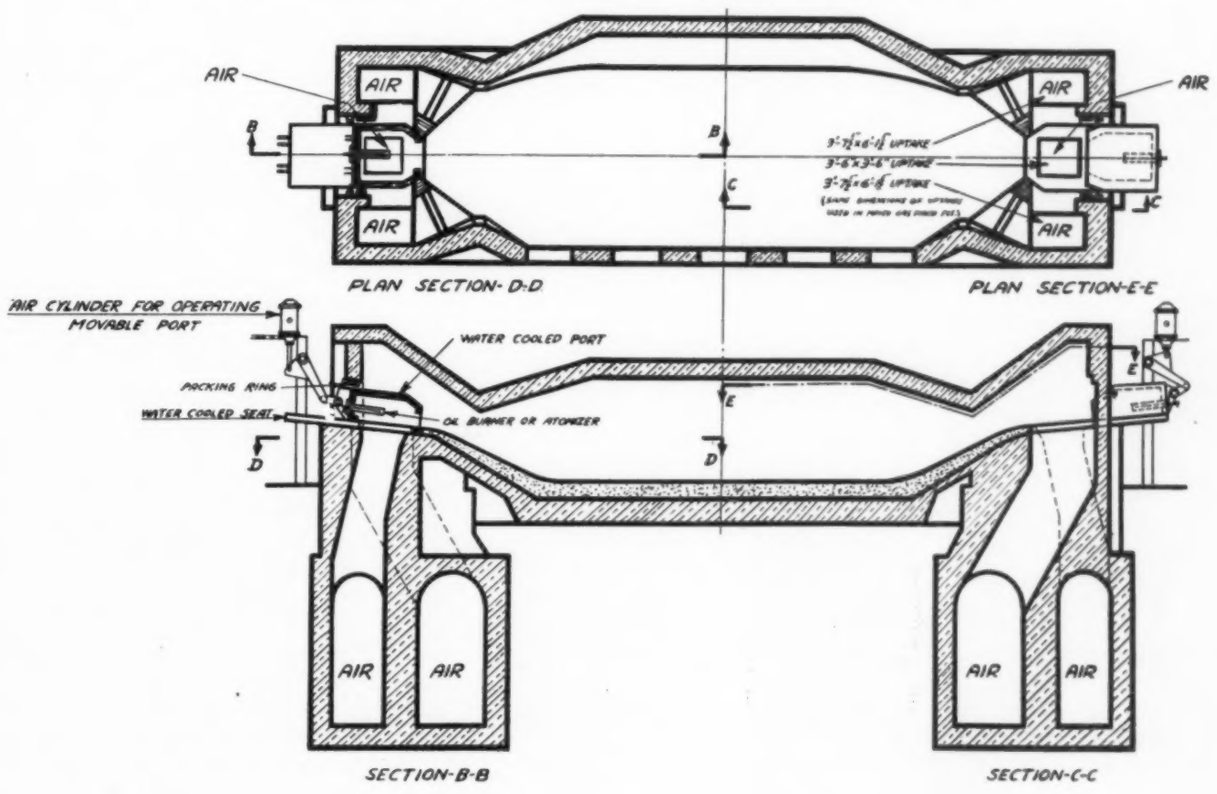
TAKEN AT ℄ OF FURNACE.

(Fig. 1)—Graph of furnace pressures in oil fired and gas fired furnaces.

operation of the open-hearth department on mixed-gas. At plants where these gases are thoroughly and efficiently handled throughout the week, but used in departments that are shut down over week-ends, such as heating furnaces and boilers, or gas engines used for generating electric power for driving mills that are shut down over the week-ends, there is necessarily an excessive bleeding of these gases, lighting up the heavens for miles around on Saturday or Sunday nights. Therefore, since the open-hearth is a much more continuously operating department, like the blast furnace and coke departments, than any other large fuel consumer in the steel plant, it would appear that the open-hearth department should be given *first call* on surplus blast furnace and coke oven gas, and some other fuel, such as fuel-oil, used under boilers or in heating furnaces on week-days, if necessary, as a make-up fuel.

One has only to visualize the ordinary oil-fired furnace and compare its combustion with that of a furnace on preheated mixed-gas to note the marked difference over the bath. In the ordinary oil-fired furnace, in which the oil burner is extended into the end of the commonly called "box-car" type of open-hearth furnace and with the oil and steam each under a pressure of 100 to 125 lbs., the mixture of oil and water-vapor (an attempt to make a gaseous fuel in the furnace) shoots forward into the furnace in an expanding cone shape, thereby sucking the air to the atomized oil. This air may come from anywhere of least resistance. The aspirating effect of the oil burner has no preference for regenerated air as compared with air that can be drawn in through the doors and wicket holes; consequently, in a furnace fired in this way, we have a large amount of air infiltration and usually late combustion, so that the furnace works on only two-thirds of its hearth area on each reversal.

(Fig. 2)—Diagram of O. H. furnace equipped with movable ports for oil burning.



This difficulty with oil burning is helped out greatly on furnaces with divided slag pockets by the use of movable ports. The oil burner or atomizer is extended through an opening in the back-end of the port to a point that brings the inner end of it approximately over the center of the former gas-uptake which on oil-burning is also being used for air. This mixes the atomized oil with a part of the preheated air inside the movable port while in its burning position and creates a beginning of the combustion at the nose of the port, approaching the favorable conditions of good gaseous-fuel firing.

No. 3 Open Hearth Furnace on Oil, with Oil Atomizers in Movable Ports

June 9, 1933 to February 26, 1934

with Movable Ports

(1) Fuel Practice, B.T.U.....	5,751,150
(2) Number of Heats.....	424

No. 6 Open Hearth Furnace on Oil, with Oil Atomizers Extending Through Stationary Water-cooled Blocks

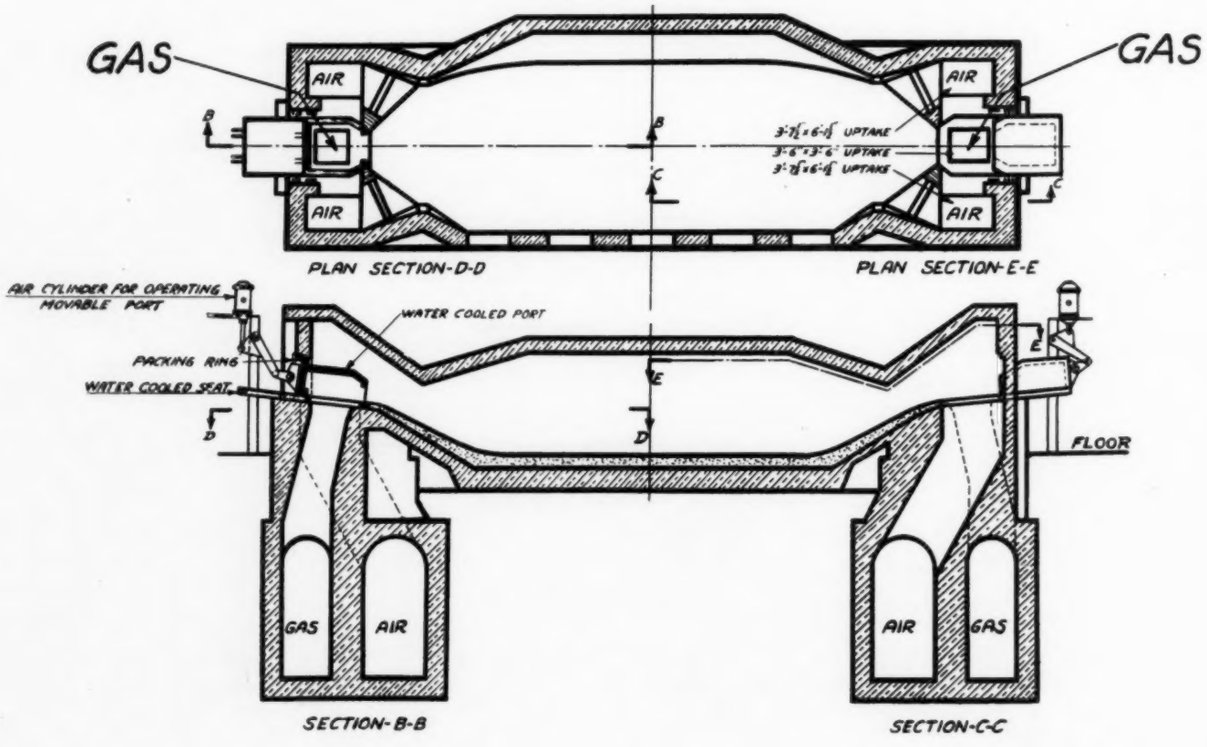
November 13, 1933 to November 26, 1934

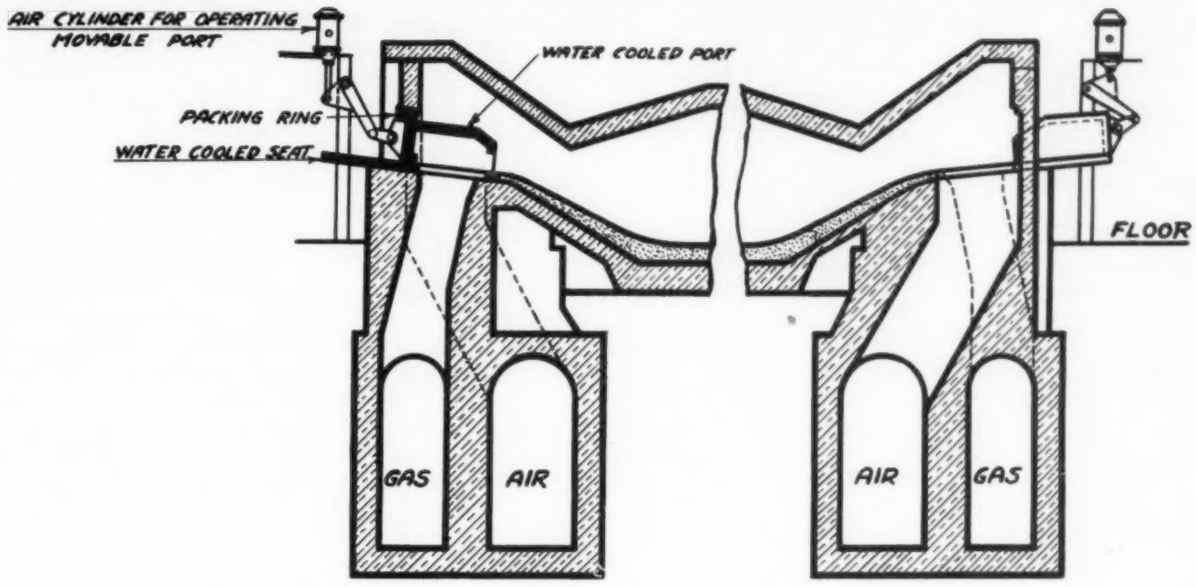
Through Stationary Water-cooled Blocks

(1) Fuel Practice, B.T.U.....	6,247,970
(2) Number of Heats.....	493
Difference in favor of the Oil fired through Movable Ports.....	496,820 BTU per ton of ingots.

Open hearth operation, however, approaches more nearly the *acme* of perfection with the use of mixed-gas as the fuel, in which case we have a highly preheated gaseous fuel under a slight pressure issuing from a restricted gas port opening of about 3.42 square feet, and the correctly proportioned amount of air to the varying quantities of coke oven gas and blast furnace gas used at the different periods of the heat, delivered to the air checkers by a fan. This measured quantity of preheated air is converged upon the gas port from which we get a very hot and luminous flame from the very nose of the port, and with a low draft on the furnace a flame that hugs the bath with slight flaming at the wicket holes, indicating no infiltration of outside air. It has been shown, as reported in our previous paper, that by preheating the mixture of blast furnace and coke oven gas to a sufficiently high temperature, a highly luminous flame is obtained. During this preheating the major portion of the methane present in the coke oven gas, as well as the major portion of the illuminants also contained in the coke oven gas, is cracked or broken down into carbon and hydrogen, the carbon formed existing as molecular carbon in an extremely finely divided form similar to lamp black. This carbon is carried on into the furnace by the current of gas and when this gas containing considerable quantities of finely divided carbon is burned in the hearth, a highly luminous flame, which hugs the bath, is obtained. The intense luminosity of such a flame gives a greatly increased transference of heat by radiation from the carbon particles. This method of heat transfer is much more efficient than any other when the bath is under cover of the slag, as slag acts as an

(Fig. 3)—Diagram of O. H. Furnace equipped with movable ports for the burning of mixed gas.





(Fig. 4)—Diagram of O. H. furnace equipped with movable ports for the burning of mixed gas.

effective insulator to heat transferred by conduction or convection.

As stated in our previous article, "The intensity of heat radiation from a given source varies inversely as the square of the distance from the source." While this law does not apply exactly to radiation from a plane or flat surface, yet the advantage of the nearness of the luminous flame to the bath, as compared with the distance from the roof of the furnace to the bath, is obvious from a radiation point of view. It should be remembered also that lamp black or molecular carbon as produced by the cracking up of coke oven gas is one of the best radiating substances known.

Heat transmitted by radiation differs from heat transmitted by conduction or convection, in that the transfer by radiation is proportional to the difference between the fourth power of the absolute temperature of the radiating substance and the fourth power of the absolute temperature of the recipient substance, while the transfer by conduction or convection is proportional to the difference in temperature. In other words, the transmission of heat by conduction or convection is the same from a body at, say, 1,000°F. to a body at 800°F. as it is from a body at 3,000°F. to a body at 2,800°F., since the temperature difference is the same i.e., 200°F. The amount of heat transmitted by radiation would be very much greater in the second case than in the first, since it is proportional to the difference between the fourth powers of the absolute temperatures. In the example given above, approximately fifteen times as much heat would be transmitted by *radiation* due to the same 200 degrees difference in temperature in the 3,000 degree zone than would be transmitted in the 1,000 degree zone. An open-hearth furnace operates most of the time in about the 3,000 degree zone. In addition, it is generally conceded that a luminous flame radiates heat from all parts of its volume, and that a hot, solid body radiates heat only from the surface.

There is a distinct advantage to the open-hearth operator using mixed blast furnace and coke oven gas, in that the B.T.U. of the fuel-gas can be varied as desired during the different stages of an open hearth heat. As an example, when charging and the doors are open, a rather lean gas mixture is used, as a high flame temperature cannot be attained with so much outside air coming in, and there is a fairly good heat transfer, at any rate, from the lower temperature to the cold scrap charge. In this way we save on the coke oven gas for use of the richer mixture later when the furnace is closed and we can get the benefits of the higher flame temperature on an increased carbon deposit in the flame from the richer gas mixture (more coke oven gas), and then, further on in the heat period when we are getting too high a temperature, we simply cut down on the quantity of the richer gas mixture.

The principal objection to the utilization of preheated mixed blast furnace and coke oven gas in open-hearth furnaces has been that it has proved to be difficult, if not impossible, when using a fixed port to force or pull out sufficient of the hot waste gases through such a fixed port and through the gas regenerators to give a sufficient supply of heat to preheat the incoming fuel-gas to the required temperature of about 2,150°F. Attempts have been made to surmount this difficulty by the use of a strong draft, which always has resulted in cutting away the stationary ports and downtakes very quickly, and without accomplishing the desired end of a sufficiently high temperature in the gas checkers.

These two sets of conditions have been met by the installation of the movable ports. With the gas port moved out of the way on the draft end of the furnace and a full opening of the gas downtake, we are greatly helped in getting the necessary quantity of the hot

products of combustion back through the gas checkers to give the necessarily high temperatures required for preheating the gas, without a strong draft pulling from the hearth of the furnace. In fact, we carry about atmospheric pressure at the door sills.

Open-hearth furnaces must necessarily be built of refractory materials, such as fire brick and silica brick. They perhaps could be entirely encased in air-tight steel plates as blast furnace stoves, but as a general practice they are not entirely so encased, perhaps largely due to the fact that generally it is necessary, during a furnace campaign, to renew or replace some of the furnace brickwork. On account of the above conditions, it behooves one, for efficient fuel economy, to create in the furnace system, both above and below the charging floor, as little draft or sub-atmospheric pressure condition as possible, with the aim of sucking in a minimum of outside air, for, as Messrs. Henry and McLaughlin state in their paper of May, 1931, read before a meeting of the American Iron and Steel Institute, such infiltration of outside air creates a "vicious circle" in diluting the products of combustion and thereby lowering the checker chamber temperatures and hence making it necessary for the burning of more fuel and therefore more air to be gotten into the system in some way for combustion of the additional fuel, and less stack draft with which to do it, due to the lower checker chamber temperatures.

The solution of such a situation we believe to be as follows: Seal the checker chambers and flue connections as tightly as practicable; force the air for combustion of the fuel into the furnace with a fan, creating enough pressure in the air so that it will combine readily with a gaseous fuel and give the required flame velocity. The gas checker chambers and connections to the burning ports must necessarily be as gas tight as possible, but from there on with large downtake openings for both gas and air, as accomplished with movable gas ports, and by keeping the stack draft low, there will not be a great amount of outside air sucked in, even though the system is not entirely air-tight, for the less draft the less air infiltration. In the past, open-hearth superintendents have seemed to fight shy of regenerating a gaseous fuel, with the thought that it was next to impossible to construct gas-tight checker chambers. It does require extra attention in construction or tightening up of existing gas checker chambers, as we have done, but even if a little fuel-gas leaks out, it doesn't result in nearly so great a financial loss as is caused by the sucking in of a lot of outside air through loosely constructed checker chambers. The difference is that any leakage of fuel-gas passing through the regenerative chambers is more obvious than the losses due to the infiltration of from 50 to 100 per cent of excess air as in the case of some open-hearth furnaces.

The very fact that the leakage of regenerated gaseous fuel is very noticeable, and therefore steps are taken to prevent it, is perhaps a very good reason for operating open-hearth furnaces with a regenerated gaseous fuel as it forces tightness in furnace construction, whereas, open-hearth furnaces in general have been causing a much greater financial loss year in and year out by infiltration of air, yet due to the fact that it has not been so noticeable, open-hearth Superintendency has "winked" at it, so to speak, and no great precautions have been taken to prevent it. (Witness paper by Messrs. Henry and McLaughlin, May, 1931, Excess Air in Stack Gases 72% and Fuel Practice, 6,155,000 B.T.U. per ton on comparatively new furnaces.)

Net efficiency of an open-hearth furnace has been described as "The heat absorbed by the charge from the combustion of the fuel in the melting chambers divided by the heat supplied by the fuel." As the heat supplied to the charge by the burning of the fuel must be sufficient, in connection with heat inherent in the charge and returned to the furnace by the regenerative system, to give the necessary temperature to the slag and metal for proper cleaning up of the heat, tapping and teeming of the steel, the *fuel practice* may be simply stated as the *heat input* of the fuel divided by the tons of ingots produced. This figure should be derived over a period of time, such as a week or month, or a furnace campaign, just as is done in blast furnace practice, when the total coke unloaded into the blast furnace bins for a month is divided by the gross tonnage of hot metal or pig iron produced to get the coke practice of the blast furnaces. Likewise, the total *B.T.U.'s of fuel* consumed for a month by a particular open-hearth furnace should be divided by its gross tons of ingots produced in the month to get the fuel efficiency of the open-hearth. The data given in this paper have been computed in accordance with the latter method. Furthermore, the gaseous fuel heating value is expressed in gross B.T.U. per cubic foot.

In conclusion, we would simply emphasize three points: First, the great advantage to be gained in open-hearth practice by the transfer of heat by radiation from the flame, especially at the high temperatures required in the latter half of the heat period and when the metal is covered with the slag. The other two means of heat transfer, viz: conduction and convection, are relatively non-effective as compared with radiation from the flame under these conditions, and we believe the open-hearth steel industry has not fully realized this fact in the past.

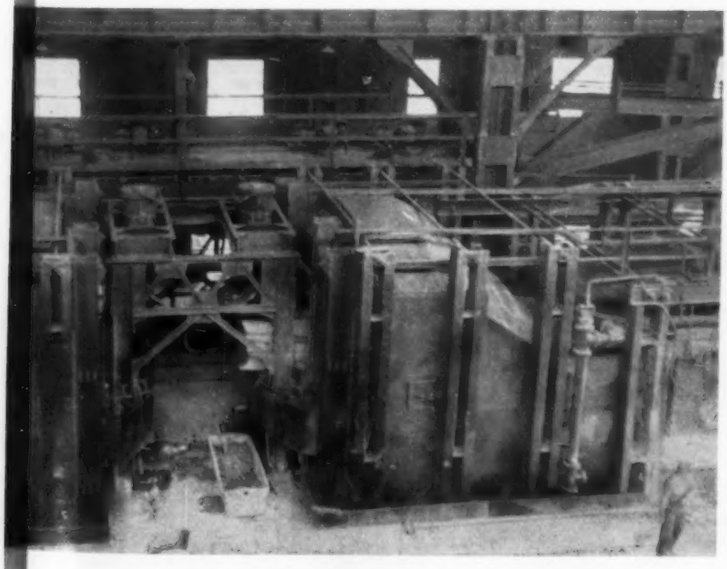
The low B.T.U. consumption when operating open-hearth furnaces on coke oven tar is another demonstration of this fact. Frequently, after a furnace has made a run of 300 or more heats on producer-gas, *coke oven tar* is turned on to finish up the campaign and the furnace, after being burnt out on the other fuel and with the checkers more or less stopped up, makes steel on about 4,000,000 B.T.U. whereas, on the other fuel and as a new furnace didn't go below 5,000,000 to 5,500,000 B.T.U. Coke oven tar is a fuel with considerable carbon in suspension and in addition is largely composed of the richer hydrocarbons of the C_6 H_6 series (rather than of the C H_4 series) and on being broken up releases more carbon per unit; hence the enormous heat transmission by radiation from the luminous flame of coke oven tar. Or witness the fact that at many steel plants it is the feeling that *unregenerated* coke oven gas can't be burnt successfully without being mixed with coke oven tar to the extent of about 40 per cent of the heat value of the fuel. The preheating of mixed-gas to about 2,150° F. takes the place of 40 per cent coke oven tar.

The second point that we would emphasize is that in regenerated mixed-gas (coke oven and blast furnace gas) we have a continuous supply of open-hearth fuel that is borne down heavily with carbon particles and that can be regulated as to richness in an ideal manner as required for the different periods of the open-hearth heat, and there is no other large *Fuel Consuming Department* in a steel plant that offers such a continuous demand for these surplus gases as the open-hearth department on every day of the week, Sundays as well as week-days.

The third and last point we would emphasize is that since open-hearth furnaces must be built of refractory materials, such as brick, they are necessarily more or less porous and hence if air infiltration is to be kept at a minimum, the sub-atmospheric conditions must be kept at a minimum in an open-hearth furnace just as in a battery of by-product coke ovens, and it also should be remembered that in the transmission of heat by radiation a rather slow velocity of the products of combustion as they pass through the furnace is greatly to be desired. For even though a high velocity of hot gases, sweeping around corners, may be conducive to increased transfer of heat by convection, it is not so in the case of the transfer of heat by radiation, which requires a more or less static situation and hence its greater effectiveness upon the bath when it is under cover of the slag.

The crux of the whole matter is that we believe we have the fuel of the *proper character* (heavily impregnated with finely divided carbon particles) by the time it arrives at the burner or port end of the furnace, while the other systems attempt to make the fuel-gas in the furnace and it is usually half way through the furnace before it is of the proper character, and in addition we use a low draft, so that air infiltration in the whole system is at a minimum, and so that less heat is sucked out of the furnace proper, all of which slower velocity of the hot-gases tends greatly to prolong the life of the checkers and to preserve the furnace walls and bulkheads.

(Fig. 5)—Movable port construction between No. 8 and No. 9 open hearth furnaces.



DISCUSSION

PRESENTED BY

J. A. CARTER, General Superintendent, Sharon Steel Hoop Company, Lowellville, Ohio

H. G. ERB, Industrial Engineer, Harrisburg Steel Company, Harrisburg, Pa.

F. M. WASHBURN, Asst. Supt., Metallurgy and Inspection, Wisconsin Steel Works, South Chicago, Ill.

K. C. McCUTCHEON, Asst. Gen. Supt., American Rolling Mill Company, Ashland, Ky.

M. J. CONWAY, Fuel Engineer, Lukens Steel Company, Coatesville, Pa.

G. E. ROSE, Gen. Supt., Wisconsin Steel Works, South Chicago, Ill.

J. A. Carter: This is a very wonderful paper and I think Mr. Washburn did a wonderful job presenting it. It deserves a lot of discussion and plenty of questions.

H. G. Erb: Are those insulated furnaces?

F. M. Washburn: Yes, they are insulated throughout—roofs, checker chambers, etc. The furnace is practically enclosed in steel plate and the checkers are enclosed in steel plate, with the insulation between the brick work and the plate.

K. C. McCutcheon: Mr. Chairman, I agree with you as to the importance of this paper. I think it shows plainly the value of the prevention of air infiltration in the checkers. Without a doubt the method of arriving at fuel consumption is a desirable one. So often we are forced to compare with figures which represent fuel consumption during the period of a heat and not for the duration of a month. For comparing one type of furnace with another, possibly the heat time is the only way to compare it in your own shop, yet to get the over-all value of a type of furnace you certainly have to know the consumption figures for a month.

I think the figures also show without a doubt the value of preheating the gas and the fact that heating the gas does give luminosity to the flame. I think it is a shame our good friend McKune is not here to argue that luminosity is not necessary at all. I think however that these figures are rather convincing that luminosity plays a big part in the heat transfer in the bath.

I think the example made as to the effect of helping out coke oven gas with tar is also quite timely and very well applied in this case, because certainly the tar is added only to add to the luminosity of coke oven gas and it does add to the steel production and cut the fuel consumption.

F. M. Washburn: I appreciate very much, Mr. McCutcheon, your agreeing with us on the proper method of reporting B.T.U. for fuel practice. It makes it so you can actually compare figures if you do it that

way, the total B.T.U. put into the furnace divided by the ingot tonnage.

M. J. Conway: I want to join with Mr. McCutcheon in offering congratulations to the authors for their excellent paper,

Referring to the table showing the preheated air and gas temperatures on Nos. 8 and 9 furnaces, I noted that the air temperature was lower than the gas temperature at the beginning of the furnace run, and during the four months furnace campaign, the air temperature became progressively lower, having dropped approximately 200 degrees. Will the authors please explain this.

F. M. Washburn: I think I can best answer that by telling you what we aim to do on these temperatures. We aim to hold the gas up to a sufficiently high temperature to get a good breakdown, and we don't make any particular attempt to control the air temperature. That gets what is left. In this particular case, we might have been putting a little more through the gas checkers. Our primary object is to hold the gas checkers up to temperature. Otherwise you do not get the proper break-down.

M. J. Conway: That answers my question satisfactorily, now I have another question. Where were these temperatures taken: At the ports of the furnace?

F. M. Washburn: No, these temperatures are taken in the hot end of the checkers, through the side of the regenerator, about a foot above the checker brick, and they are taken about midway from front to back of the pass. In other words, the thermocouple is in the gas stream as it comes down through the first pass of the checkers, catching it before it goes through. At this point, the temperature is high enough so we have a great deal of difficulty in maintaining the thermocouple.

K. C. McCutcheon: It seemed to me a possible explanation of that, as I looked at it, would lie in the fact that as far as the air is concerned, there is no way you can prevent infiltration in the checkers inasmuch as you are relying upon the natural draft of the heat of the uptake to pull the air in from the checkers to the uptake and you have no restriction to the air coming in. On the contrary, with the gas, you close the gas uptake, with the port, and therefore your gas must come in under pressure and will be under positive pressure up to the nose of the port and thus prevent air infiltration on the incoming end.

F. M. Washburn: Of course, our air is under positive pressure also from the fan.

K. C. McCutcheon: You will find that you have negative pressure probably in the top of the first pass of the two pass checkers. As it goes on from there it will be in draft, becoming positive only towards the top of the uptakes.

F. M. Washburn: I will agree with you there, and negative from there on.

K. C. McCutcheon: From there you will be negative, and progressively in the life of the furnace you will have more and more infiltration both in the incoming and outgoing end, and it will tend probably to arrive at lower preheat because there will be the mixture of cold air on the incoming end and lower checker preheat on the outgoing end.

F. M. Washburn: That is true, of course. You get some infiltration. We do endeavor to run on as low a draft as possible, naturally, and we have our checkers pretty well tightened up. They are enclosed in steel plates and we take great care to maintain them as tight as possible.

G. E. Rose: Of course, with the use of Blaw-Knox slide valves for reversing, one can adjust the cables on the valves on the gas flues so that they will be wide open on each reversal, and adjust the cables on the corresponding valves on the air flues so that they will not give a full opening of the flue and therefore not so much of the products of combustion will be sucked back through the air chamber as would be the case if the air valve opened all the way. In other words, such adjustment of Blaw-Knox slide valves for reversing gives the gas checker chambers preference.

K. C. McCutcheon: You are talking about the outgoing side?

G. E. Rose: Yes, to keep up the temperature of the gas checker chambers. In the No. 1 furnace, the older one, we were not able to get more than 1,500° to 1,600°F. in the air if we got 2,050° or something like that in the gas.

K. C. McCutcheon: Mr. Washburn I think explained that you do draw less of the products through the air chamber.

G. E. Rose: We keep the gas up to 2,150°F. or as near to that point as possible. In the new No. 8 and No. 9 furnaces we can average 2,150° F. in the regenerated gas and let the air take what is left, on the theory that it is more advantageous to us to keep the gas temperature up to a point that is sufficiently high for breaking down the hydrocarbons in the mixed gas, rather than to get more physical heat in through the air, *the quality of the fuel being the paramount issue,* as we see it. This point was demonstrated as reported in our former paper of 1930 when we installed the movable ports. You will recall the third campaign on the No. 1 furnace, the last campaign before installing the movable ports, showed a fuel practice of 4,989,710 BTU per gross ton of ingots, and the fourth campaign, with movable ports, 4,518,560 BTU per gross ton of ingots. "You will note that we got the preheat up in the gas in the fourth campaign at the expense of the preheat in the air, as compared with the third campaign, viz:

Third campaign, Gas Preheat 1,808°F., Air Preheat 2,006°F.

Fourth campaign with movable ports, Gas Preheat 1,996°F. Air Preheat 1,666°F.

This was possible with the movable Ports, giving us an open-end furnace in conjunction with the Slide Valves for reversing with which we could make any division we wanted of the products of combustion between the gas and air checker chambers."

ARC WELDING APPARATUS

THE DEVELOPMENTS IN ARC WELDING

BY E. STEINERT and W. W. REDDIE
Westinghouse Electric & Mfg. Co.

Paper presented before the A. I. & S. E. E. Convention, Pittsburgh, Pennsylvania, September 24, 25, 26, 1935

▲ THE QUESTION is frequently asked in discussions of arc welding apparatus, why is alternating current welding experiencing so much of a revival and increased use when fifteen years ago it received what most engineers considered a fair trial, and was set to one side in favor of direct current welding.

Four major reasons may be given: The extension of electric arc welding into fields which did not exist fifteen years ago, the development of suitable electrodes for alternating current welding apparatus and recognition of certain superior qualities of the alternating current welding arc.

The primary function of the transformer welder is to correct A.C. power of commercial characteristics to a form suitable for arc welding purposes. In order to perform this function economically and satisfactorily, the welder must meet the following requirements.

(1) It should safely insulate the secondary or welding terminals from the primary line voltage. This requirement is met by the use of two winding transformers in which the secondary winding is completely insulated from primary. Auto-transformer type welders do not fulfill this requirement and are, therefore, a source of danger.

(2) It must transform from an economical shop distribution voltage to a suitable welding voltage. Practically all standard alternating current arc welders are designed for a dual primary voltage of 440 or 220 volts. This meets the requirement of a large majority of installations.

(3) The third requirement of an A. C. welder is that it should have characteristics necessary for the production of a stable arc.

(4) It should have suitable open circuit voltage characteristics and preferably a means of reducing or eliminating the open circuit voltage when not welding.

(5) Convenient means for adjusting the welding current over a wide range must be provided.

The first two requirements call for no further discussion.

The requirement of arc stability involves a consideration of some of the fundamental characteristics of an arc and the factors which influence its stability.

The effective voltage across an a. c. arc varies from 20 to 35 volts, depending on the type of electrode used and the length of the arc. For design purposes, an arc voltage of 30 to 40 volts is used which includes an allowance for lead drop.

Due to the negative resistance characteristics of an arc, it is essential to have additional current limiting impedance in series with the arc in order to produce a stable electrical circuit. Furthermore, due to the fact that the arc voltage is practically constant and independent of the current, it is necessary to provide the same open circuit voltage for all values of welding current. The only means, therefore, of adjusting the circuit to give the desired welding current is by means of a variable series impedance. This impedance may be either non-inductive resistance or reactance—either one will produce a stable electrical circuit but the arc characteristics will be widely different.

When resistance is used as a current limiting impedance the current will be nearly in phase with the applied voltage. At the instant the current wave passes through zero, the applied voltage is also at the point of reversal. At this instant, the arc is extinguished and there is no voltage available to re-ignite the arc. The arc remains extinguished until the applied voltage, which increases sinusoidally from zero, reaches the value required for re-ignition of the arc. This periodical absence of current at each reversal of polarity (occurring 120 times per second) allows the point of application of the arc to cool, resulting in an arc which is difficult to strike and hold. It is obvious that if an additional high frequency voltage were superimposed on the 60 cycle voltage at the arc the path of the arc would be maintained in a state of ionization and the welding current would vary sinusoidally with the power voltage thus eliminating the dead periods.

When reactance is used as a current limiting impedance instead of resistance, the current is out of phase with the impressed voltage. Under average conditions of power factor this phase displacement amounts to approximately 65 degrees. Therefore at the instant of current reversal the applied voltage is at approximately 90% of its peak value. This voltage is, in general, sufficient to re-establish the arc immediately at each reversal of polarity without lapse of time as would be the case with resistance control. A reactance controlled alternating current welder therefore possesses inherent arc stability.

Referring to our fourth requirement, the open circuit voltage of the a. c. arc welders must be sufficiently

high to insure good welding characteristics while from the standpoint of efficiency, power factor, cost of apparatus and safety, it is desirable to use as low an open circuit voltage as possible.

The voltage required depends to a large extent on the type of electrode used and consequently there is still some difference of opinion as to what this voltage should be. Experience has shown that 80 volts is a satisfactory voltage for use with a reasonably good quality of a. c. electrode. The adoption of 80 volts as standard open circuit voltage for transformer type welders is under consideration.

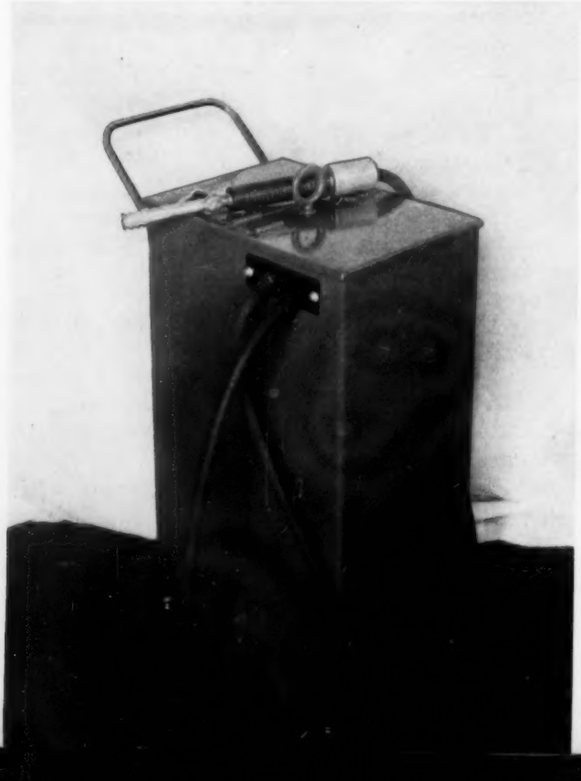
The voltage which must be used for satisfactory AC arc welding, however, is somewhat higher than that to which direct current welding operators are accustomed. It is desirable, therefore, to educate the operators in the proper use of the equipment to avoid accidents. No voltage control scheme has yet been devised which insures 100% security against shock. Several practical schemes, however, are in commercial use which greatly increase the safety of operation.

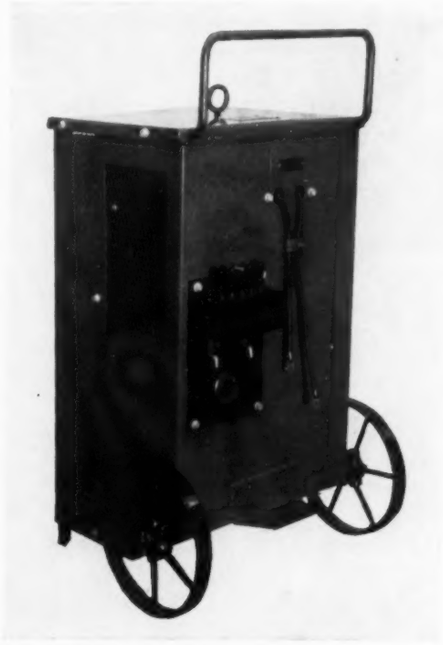
The simplest of these schemes consists of a contactor which disconnects the welder from the line. The contactor is controlled through an auxiliary pilot circuit by a switch in the handle of the electrode holder. The welder terminals are energized only while the operator holds the switch lever on the holder in the closed position. The scheme also eliminates the no load losses of the welder and is used to a large extent on welders of the lower current ratings.

A second scheme consists of a contactor and an automatic time delay and relay circuit. The contactor switches the connection from the normal full secondary winding to a reduced voltage tap of approximately 50% of the normal open circuit voltage. During the condition of open circuit the welder is connected to the reduced voltage tap. When contact is made between the electrode and work, a small current flows which operates a relay causing the contactor to switch to the full secondary winding. This connection is maintained so long as an arc is held and for an adjustable period of approximately two seconds after the arc is interrupted. The purpose of the time delay is to prevent frequent operation of the contactor due to short accidental interruptions of the arc.

A third scheme, operating by means of a relay and time delay circuit, completely de-energizes the transformer when not welding. A pilot circuit, controlled through a button switch in the electrode handle, causes the control to function when the operator makes momentary contact with the switch, thus energizing the transformer through closing contactors in the primary loads.

(Fig. 1)—100 Ampere A-C welder. Range 30 to 150 Amps.





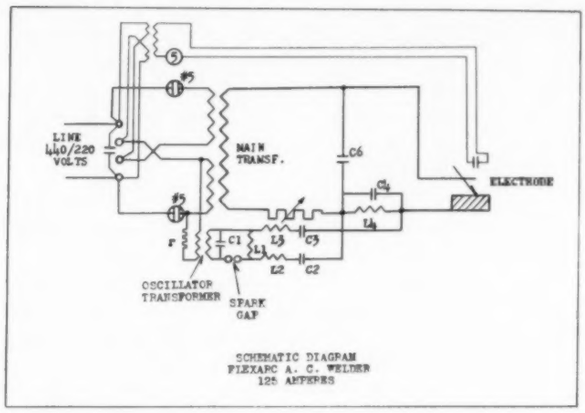
(Fig. 2)—125 Ampere AC welder with high frequency arc stabilization. Welding range 5 to 125 Amperes.

In regard to adjustment of welding currents, several schemes of current control are commercially used at present. These are resistance control employing short circuiting switches and reactance control, by means of tap changers, moving coil, or moving core.

The resistance type of current control is perhaps the simplest requiring only a group of resistor elements connected in series with several switches for shorting-out sections of the resistor. A large number of steps can be obtained with relatively few switches. Due to its simplicity, low weight and cost and the fact that it gives a high power factor at the expense of efficiency it is adapted only to portable low current ratings. Satisfactory performance requires the addition of super imposed high frequency for arc stabilization.

Under the reactance type of current control the tap-changer scheme is used to a large extent on small and intermediate ratings. Means are provided for changing taps on a series reactor or if the reactance is built into the transformer, taps are changed on both the primary and secondary windings simultaneously to vary the reactance and maintain constant voltage ratio. This scheme is at disadvantage on welders of the higher

current ratings due to the fact that it involves switching electrical connections which must carry current of considerable magnitude, current adjustment is obtainable only in definitely fixed steps and the current cannot be adjusted while the welder is operating.



(Fig. 3)—Schematic diagram of 125 ampere 125 AC welder with high frequency arc stabilization.

The moving coil design of reactance control provides an infinite number of welding current settings without necessity for switching electrical connections. The disadvantages of this type are, a mechanically weak moving coil which must be supported and guided over its range of travel, heavy flexible leads which must be supported and guided over its range of travel; heavy flexible leads to the moving coil which must carry current of considerable magnitude and are therefore subject to breakage due to repeated bending.

The moving core scheme of control is particularly well adapted to welders of the higher current ratings. This type possesses the combined advantages of the tap changer and moving coil schemes. The windings are rigid and fixed in position, no electrical connections need be changed over a wide range of settings, a particularly infinite number of current settings are obtainable and the current may be adjusted while the welder is in operation. This scheme of current control has not received the popularity it deserves until comparatively recently due to the difficulty of designing it so that vibration and attendant noise of the moving core would not be excessive. A design of this type has been developed employing a resilient mounting for the moving core and other special features for reducing and absorbing the vibratory magnetic forces.

Current control schemes for a. c. arc welders employing electronic devices have been prepared but so far as these have not been found commercially feasible due to the high cost of the equipment.

With the foregoing discussion in mind, brief reference will be made to several typical designs of welders.

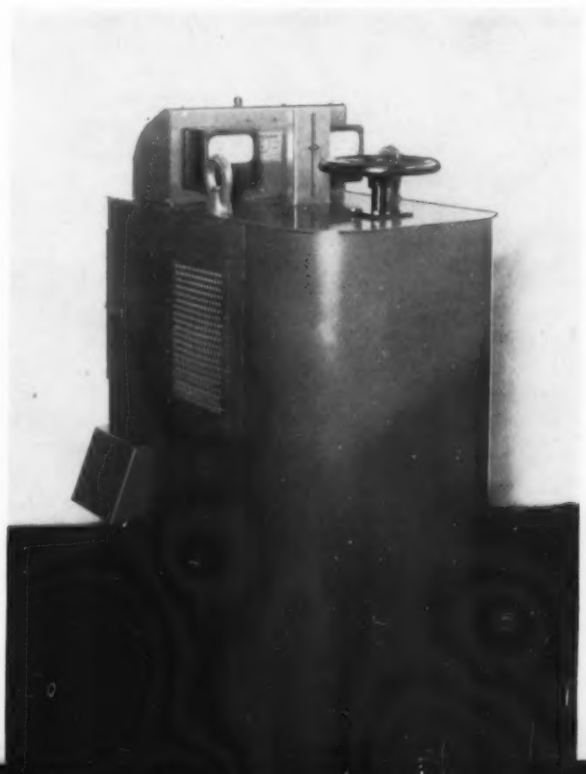
Alternating current arc welders of the transformer type may be divided into three general classes, two of these covering a line of ratings approximately 300 amperes and below and the third covering ratings larger than 300 amperes.

The first of these classes includes primarily portable machines employing reactance control without additional means of arc stabilization intended for use with coated electrodes and for use where unusually light current welding is not required. A typical welder of this class is illustrated in Fig. 1. The unit is readily portable, is rated 100 amperes and has a current range of 30 to 150 amperes obtainable in fifteen steps of equal increments by means of a simple plug and receptacle reactor for changing taps. Access to the line terminal board and the tap changing board is provided by two separately hinged covers. This type of unit finds wide application in garages, repair shops or on light production work. Its average efficiency is 85% and has a power factor of approximately 50%.

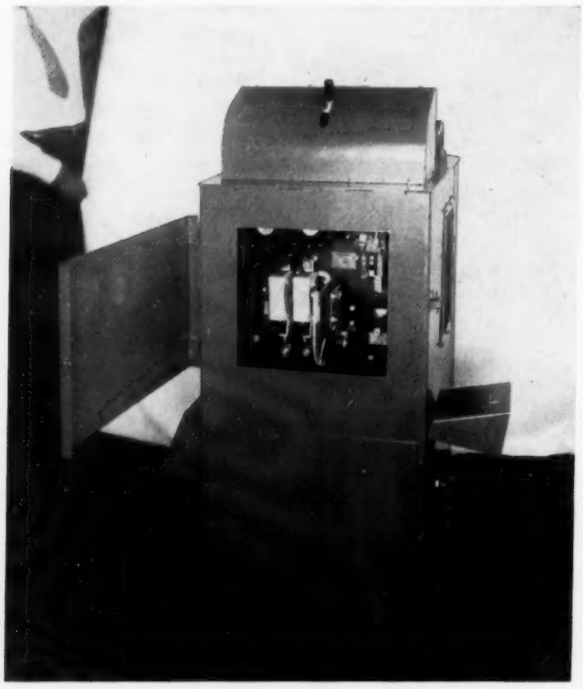
The second class of a. c. arc welders includes portable designs of ratings similar to those in class 1 except equipped with a high frequency oscillator to improve the arc stability. This class of welder is designed for more general application in connection with either bare or coated electrodes and is particularly well adapted to the welding of light gauge sheet metal requiring very low welding current and exceptionally good arc stability. The superimposed high frequency makes the arc easy to strike and manipulate by maintaining a constantly ionized arc path during current reversals. Due to its ease of manipulation at exceptionally low welding currents this welder has opened a field in arc welding of light gauge metals which was previously confined to gas welding. Fig. 2 illustrates a welder of this class rated at 125 amperes with a current range of 5 to 125 amperes. This design employs resistance control, high frequency arc stabilization and is adapted to high class production work with either bare or coated electrodes. Fig. 3 shows a schematic diagram of the circuit including the high frequency oscillator which is specially designed for elimination of radio interference.

The third class comprises heavy duty arc welders

(Fig. 4)—500 Ampere AC welder. Welding range 100 to 500 amperes, moving core type control.



with representative ratings of 500 to 750 amperes. This class is usually designed for stationary mounting (though it is sometimes made portable) and finds its application in industrial shops in the fabrication of heavy pressure vessels and similar structures. These welders employ reactance for current control and are designed for use with coated alternating current electrodes. The lower value of the welding current range is ordinarily not much below 100 amperes and the arc characteristics and manipulation are good over the entire welding range when using suitable a. c. electrodes.



(Fig. 5)—500 Ampere AC welder. Welding range 100 to 500 amperes. View shows voltage control.

Figure 4 illustrates a design of this class recently developed which employs the moving core type of control. This design is rated 500 amperes with a current range of 100 to 500 amperes. In order to provide a uniformly fine current adjustment over the entire scale, the current range is divided into two parts, namely 100 to 170 and 170 to 500 amperes. Both of these current ranges are obtained with the same core travel. An externally operated knife switch provides for switching from one range to the other. By this means exceptionally fine current adjustment is obtainable over the entire range down to the lowest current setting. A pointer and scale indicates the approximate welding current corresponding to the position of the moving core. The welder has a dual primary voltage rating of 440 to 220 volts. Although the welder is designed for the standard open circuit voltage of 80 volts, taps are provided for obtaining 70, 90 or 100 volts.

This welder is also equipped with a voltage control illustrated in figure 5, which automatically disconnects the welder from the line when not welding, thereby eliminating the no load loss and increasing the safety of operation.

Figure 6 is a schematic diagram of the 500 ampere welder previously illustrated. Closing of the pilot circuit for an instant short circuits the SV relay contacts and causes the main contactor No. 5 to close. If no arc is struck the contactor will again open after a delay of two seconds. If an arc is struck the voltage drop across the reactors, to which the SV relay coil is connected, will hold the SV relay contacts in the closed position thereby holding the main contactor closed. When the arc is interrupted the SV relay opens and after a two second delay the contactor also opens, de-energizing the welder. This scheme has the following advantages:

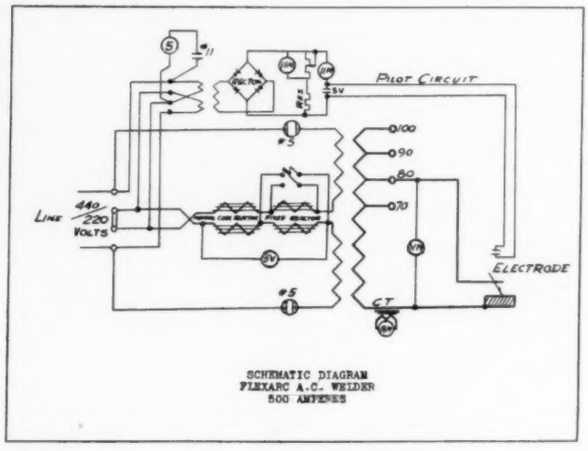
(1) The main contactor is connected on the primary side, therefore requiring a smaller contactor with less maintenance due to the lower current rating.

(2) It relieves the operators of the necessity of holding in the control switch while welding and insures that the contactor will function when welding ceases.

(3) The control is started by momentary depression of the button switch eliminating necessity for establishing good contact between electrode and work.

((4) It reduces the no-load losses to the negligible amount required by the small control transformer.

(5) It completely de-energizes the welding terminals automatically when not welding thereby increasing the safety of operation.



(Fig. 6)—Schematic diagram of 500 Ampere welder showing scheme of current control and control circuit for automatically de-energizing welder when not welding.

With suitable apparatus and electrodes available, the choice of or the use of both types alternating current and direct current, will be influenced by type of work to be done and power supply conditions. The trend to more extensive use of alternating current is found at each end of the welding range, in light current work on thin sheets, and in heavy current welding in pressure vessel and tank shop work, particularly in Class I and Class II welding requirements. Low operating power factor has been advanced as an objection to the use of a. c. welders. However, a study of the welding advantages of a. c. in specific applications may and has frequently justified the additional investment in capacitors for power factor correction.

LUBRICANT SPECIFICATIONS

THEIR DEVELOPMENT FOR THE STEEL INDUSTRY

By O. L. MAAG, Lubrication Engineer
THE TIMKEN ROLLER BEARING COMPANY

Paper presented at A. I. & S. E. E. Convention, Pittsburgh, Pa., September 24, 25, 26, 1935

▲ LUBRICATION PLAYS an extremely important part in the operation of any industrial plant, and particularly so in the case of a modern steel mill, which is a complex organization offering the lubrication engineer perhaps a wider range of problems than any other industry. All degrees of speed are encountered and loading ranges from light to extremely severe. Wide temperature variations must be handled. Water, dirt and grit conditions complicate the situation. To solve all of these problems economically is a real task. No one has yet solved them all, but we are all trying, and that is what makes for progress.

As the application of anti-friction bearings continues to increase in the steel industry, new problems arise, and the Timken Roller Bearing Company has endeavored to keep abreast of the situation, realizing that proper lubrication is one of the essentials required for the efficient and economical operation and long life of any bearing, regardless of whether it is a plain journal or a Timken Tapered Roller Bearing, whether it is in a shop truck or on the back-up or work roll neck of the largest rolling mill.

Not so long ago, lubrication was a matter of cut and try, a question of individual judgment, prejudice and experience. There were few standards that an operating man could really depend upon. Today we have at our disposal chemical laboratories to check up on the structure of the lubricant, physical laboratories to tell us whether the product can meet our needs, testing machines which simulate actual working conditions to correlate the knowledge we have gained from our chemical and physical tests. As a result, we now have workable specifications which serve as dependable guides to operators. These questions as they apply to tapered roller bearings will be discussed in this paper. In the case of anti-friction bearings the lubricant must act to:

1. Still further reduce the slight internal friction in the bearing.
2. Dissipate heat.
3. Aid in keeping out foreign matter such as water, scale, etc.
4. Prevent rust and corrosion.

Heat in an anti-friction bearing may be due to a number of causes. If the bearing is overloaded, distortion of races and rollers as they enter and leave the load zone may cause a serious rise in temperature. The use of too much, or the wrong consistency lubricant may cause a rise in temperature. In some cases the surrounding atmosphere may reach a temperature actually injurious to the bearing, due to poor ventilation, etc. However, it is fundamentally the function of the lubricant to dissipate the heat and protect the bearing.

In steel mills it is expected that the lubricant will aid in keeping foreign matter out of the bearings. This of course is mainly done by the closures, but the use of the correct kind and grade of lubricant will make the problem easier and the whole operation more efficient. When the lubricant is expected to function in part as a seal and prevent the entrance of foreign matter, it is essential that the proper consistency for the particular application be selected. Special emphasis should be given in this case to the requirement that the lubricant should not thin out too much in service.

The highly polished steel surfaces of anti-friction bearings are easily attacked by rust and corrosion, and the lubricant must prevent this attack, thereby maintaining the smooth surface so essential to friction-free operation. During shipment and in storage bearing surfaces are carefully protected with a grease or oil coating, and after installation it is the function of the lubricant to maintain a rust and corrosion proof coating on the operating surfaces at all times. In this connection it is well to add a word of caution to operating men, and that is to watch their lubricants and see that they are always up to specifications for their intended application. The laboratory can be of great value to the operating or maintenance department in this connection.

In order to clarify certain terms which must necessarily be used in specifications for lubricants, we may pause now to consider the standard tests used in determining the properties of oils and greases and to discuss briefly the development and use of the Timken Lubricant Tester which affords operating men a quick and practical check on the value of lubricants under operating conditions.

To determine the gravity of an oil, or its Baumé rating, an oil hydrometer (similar to the ordinary battery tester) is used. This hydrometer is standardized to read correctly only at 60° F., so the oil must either be at that temperature when the reading is taken or a correction must be made mathematically. Usually

gravity readings are taken at room temperature and corrected to 60° F. by the use of standard tables.

All petroleum lubricants will burn if conditions are right, and to determine the fire hazard the Flash and Fire test is of value. This consists of raising the temperature of the oil in a specially designed dish at a rate not exceeding 30° F. per minute until a point is reached approximately 100° F. below the probable flash point. From this point on the temperature rise should not be less than 9° F. nor more than 11° F. per minute. An open flame is passed over the oil at

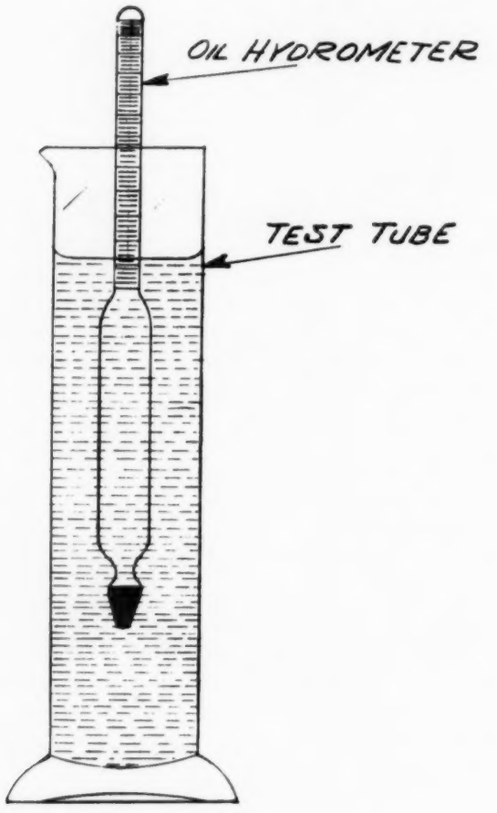


Fig. 1—Gravity Test

regular intervals and the flash point is that temperature when there is a sudden flash of flame on the surface of the oil. The fire point is that temperature at which the oil ignites and burns steadily for at least 5 seconds.

The Cold Test and Pour Point Tests are designed to show how oil behaves under low temperature conditions and consist of bringing the temperature of the oil down until a cloudiness or haze appears in the specimen, indicating the formation of wax crystals. The Pour Point is the temperature at which no movement can be detected in the oil when the test tube containing the sample is held horizontal for five seconds.

The Percentage of Water in a lubricant can be readily determined by a simple process of distillation, the condensate being collected in a graduated tube. Another commonly used method for determining the amount of water present is that of centrifuging the sample.

Viscosity, as applied to lubricants, is determined almost entirely on the Saybolt Universal viscosimeter in this country and indicates the length of time in seconds that it takes for 60 cc. of an oil to pass through a standard orifice, temperature being maintained at a standard temperature, usually 100° F., 130° F., or 210° F.

Consistency of a grease means very much the same as does viscosity as applied to oils. Our usual method for determining consistency consists of dropping a standard iron ball weighing 4 ounces into a level sample, the drop being 12 inches. The depth of penetration of the ball into the sample is considered as a measure of the consistency of the grease. This method has proven quite satisfactory for medium consistency greases of the lime soap type, but is not accurate enough for the soft products. The A.S.T.M. Penetration Test is quite generally used also and consists of measuring the depth to which a standard cone with a needle point penetrates into a sample of grease. Criticism that we have received on this method is that with greases whose penetration numbers come in the range where the needle flares out to the cone the values are not consistent, as in some cases visual inspection indicates quite a difference in consistency where the actual instrument readings are quite close.

Best check data can be obtained on samples of grease that have been mechanically worked after cooling. This destroys the set that develops when the containers are filled with grease from the compounding kettles. When studying greases for use in anti-friction bearings, the so-called "worked" consistency is of most interest, as that closely approximates the consistency of the grease on which the bearing must operate. It also gives an indication as to whether or not the grease will thin down in service and give rise to leakage trouble. In some instances milled or worked consistency greases are already being demanded by operators in order to reduce their leakage problems.

To meet the need for a simple machine for measuring the film strength or load carrying capacity of a lubricant, the abrasiveness or tendency to cause wear on gears or bearing parts, its stability, etc., the Timken Lubricant Tester was developed. Data obtained on practical operating installations indicate quite conclusively that lubricants that show wear on the test machine also produce wear in practical operation.

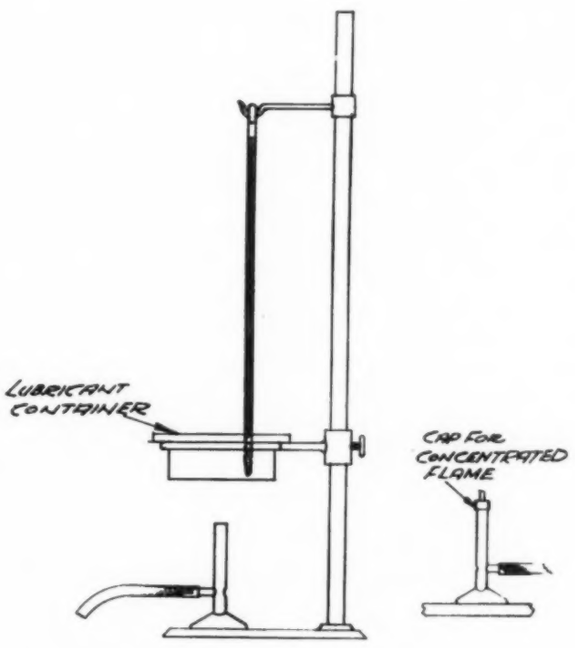
A lubricant testing machine is now being brought out by the S.A.E. in conjunction with the U. S. Bureau of Standards to replace the several types now in service. This new machine is designed with the idea of combining the best features of all the other machines in a single standard unit. It will combine both the sliding and rolling motion, which corresponds to the action in hypoid gears, by using the two standard Timken test pieces running at different speeds, thereby extending the field of investigation.

The Timken machine has been extensively used in connection with experimental work done in the development of extreme pressure lubricants, and specifications for lubricants recommended for use with Timken Bearings are based on data secured with this

machine and substantiated in practice. Straight mineral oils increase in film strength as their viscosity or body increases, as shown in Table I. In the case of extreme pressure lubricants however, the chemicals used and their special properties, together with the method used in compounding the lubricant, are the important factors.

Table 1—Relation of Film Strength to Viscosity.

Be′ at 60° F.	Viscosity at 210° F.	Load on Lever Arm —Lbs.	
		O.K.	Score
27.4	40 sec.	1	2
21.0	48 "	5	6
22.0	65 "	7	8
26.9	73 "	9	10
26.6	99 "	11	13
25.8	124 "	13	15
25.7	153 "	15	17
22.6	180 "	18	20



(Fig. 2)—Fire and Flash Test.

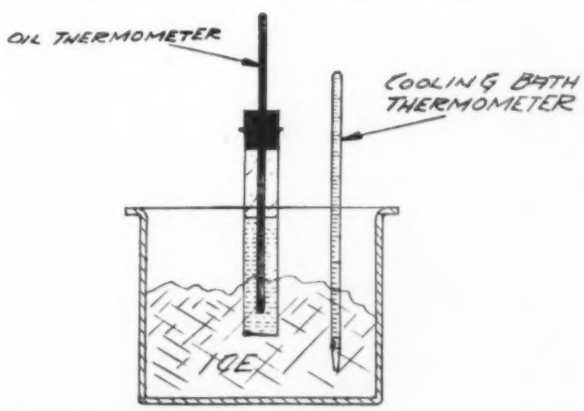
In testing extreme pressure lubricants for abrasion on the Timken Lubricant Tester a 33 pound lever load is generally used, giving a loading on the test specimen of approximately 20,000 pounds per square inch. This test is continued for a period of 6 hours, and for acceptance no scoring should appear on the specimen. For lubricants not designed to carry such a heavy load, a lighter lever load must be used for the wear test. Determination of the load carrying capacity of a lubricant after a 6 hour test run gives a good indication of its stability. Some lubricants show a decided loss, while others apparently are not affected. Laboratory work has indicated that those lubricants which decrease in load carrying capacity also show a marked decrease in sulphur or chlorine content. Further, this work indicated that extreme pressure products compounded from a well refined mineral oil and an extreme pressure base such as a chlorinated oil were more stable than those made from dark, unrefined oils. In the manufacture of lubricants for the automotive trade many manufacturers now use only refined stocks in compounding E.P. lubricants. Viscosity tests before and after the 6 hour abrasion test indicate whether or not the lubricant will thicken in service. Investigations and experience show that in a considerable number of instances lubricants that increased in viscosity during the test thickened up quite badly in service.

Both sulphur and chlorine act in much the same way in increasing the load carrying capacity of a lubricant, as will be seen from Table II. Recent work indicates that phosphates must also be considered, as some have already shown merit.

Table II.

Lubricant	Specimen	O.K. Load	Wear 6 hrs. with 33 lb. Lever Load
Chlorinated Oils	No. 1	100 lbs. plus	.0035 grams
	" 2	95 "	.0030 "
	" 3	100 "	.0045 "
	" 4	95 "	.0020 "
	" 5	59 "	.0050 "
Sulphurized Fatty Oils	" 1	43 "	.0070 "
	" 2	43 "	.0150 "
	" 3	33 "	.0050 "
	" 4	33 "	.0055 "
	" 5	43 "	.0080 "
	" 6	43 "	.0075 "

Load carrying capacity is affected by an increase in rubbing speed. Increasing the sulphur content in-



(Fig. 3)—Cloud and Cold Test.

creases the abrasive properties of the lubricant, while increasing the chlorine content apparently reduces the abrasion while at the same time increasing the load carrying capacity of the lubricant. Our experience, particularly in connection with steel mills, has been that lead soap extreme pressure lubricants have been more widely used than any other type. Hexachlorethane, chlorinated retene, and certain other definite chemical compounds including phosphates, have also shown merit and will undoubtedly find their proper field of service in lubrication.

We probably will always have with us the man who says "If a little is good, a lot is better". This is as great a fallacy in bearing lubrication as it is in medicine or anything else. If too much or too heavy a lubricant is used there is bound to be an increase in temperature when the machine starts, usually followed by leakage. An attempt to stop this by tightening the closures will increase the friction, thus still further aggravating the condition until in extreme cases the bearing fails.

This trouble is usually encountered in warm weather and is due to the churning action set up by the bearing parts in their operation. As the temperature rises, the film strength or lubricating value of the lubricant decreases, the oil or grease becomes thinner and thinner, and either enough leaks out of the housing to save the situation or trouble follows.

High temperature conditions are likely to cause foaming and separation of soap and oil, particularly when the greases contain moisture. The oil may drain out, leaving only the heavy soap in the housing. When this occurs the lubricating value of the grease is seriously affected and it is advisable to clean out the bearing and housing and start over, using just enough grease. It is quite likely that in the near future operators will insist upon having a grease that is practically moisture free, permitting less than 1% of water.

When it is known that a bearing will be subject to high temperature under operating conditions, special lubricants should be used. Greases for use under these conditions should be of such a character that they will return to their original consistency when the bearing cools with practically no oil separation. The following laboratory test for this property was developed and is being used by British Timken Limited in their laboratories.

SEPARATION TEST

"25 grams of grease are heated to 250° F. and held at that temperature for half an hour, then poured into a Silica Tube, which when cool is suspended over a conical measure, graduated in c.c.'s., in which the mineral oil that separates out in 48 hours is collected.

"Greases showing separation to be rejected.

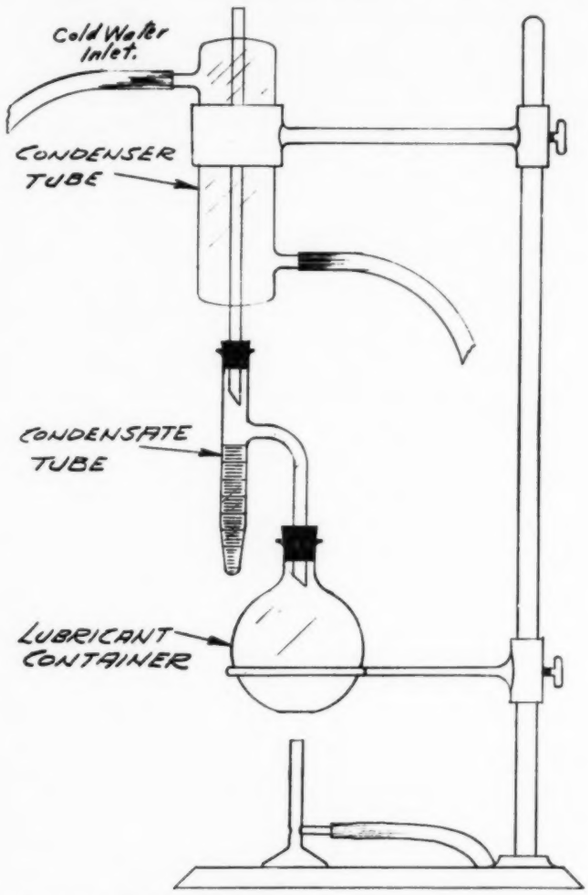
MANIPULATION

"25 grams of grease are melted in the standard Pensky Martin Flash Point Cup, and heated at the rate of 10° F. per minute to 250° F. The grease is maintained at this temperature for half an hour.

"During the heating and maintaining the grease is to be stirred at the rate of 2 revs. per second for alternate minutes.

"After the grease has been held at a constant temperature of 250° F. for half an hour it is poured into a Silica Tube, approximately 3" long by 1" inside diameter, one end of which has been previously sealed with a cork.

"After half an hour atmospheric cooling, the cork is removed, and the grease, supported by two pieces of



(Fig. 4)—**Distillation Test for Percentage of Water.**

flattened wire, approximately 1/16" wide, wound vertically round the tube, is suspended over a conical measure graduated in c.c.'s.

"The oil collected after 48 hours x 4 = % separation on 100 grams of grease."

Likewise, unless care is exercised in selecting the proper lubricant the reverse condition may be encountered in cold weather. If the lubricant will not flow, the bearing rollers or gears will merely cut a channel through the stiff oil or grease. This is particularly serious when bearing lubrication is dependent upon splash from the gears. In certain cases this difficulty can be overcome by making provision for the installation of a steam coil to thin the lubricant in cold weather. This, however, is frequently difficult to do, and consequently special thought should be given to the selection of the lubricant best suited to meet the conditions that will prevail without the use of special heating devices.

If the grease in a bearing is not renewed for a long

time, a deposit of a lime or soda soap may form in the housing, reducing the space available for the effective lubricant. Proper attention to lubrication will of course prevent such a condition. And finally, there is the situation that develops when a grease is used that is too heavy to flow into and around a bearing. When this occurs and the bearing has not entirely failed, we find it discolored even though there may be plenty of grease in the housing. The heat has melted the stiff grease before complete failure occurred and caused it to flow in and cool the bearing. Such a condition usually requires the replacement of the bearing, but should never be permitted to occur.

Thus the precautions necessary to insure proper lubrication will be seen, and we will move along to discuss the types of lubricants most frequently used in steel mills, the way in which they are ordinarily used, and the specifications which have been developed.

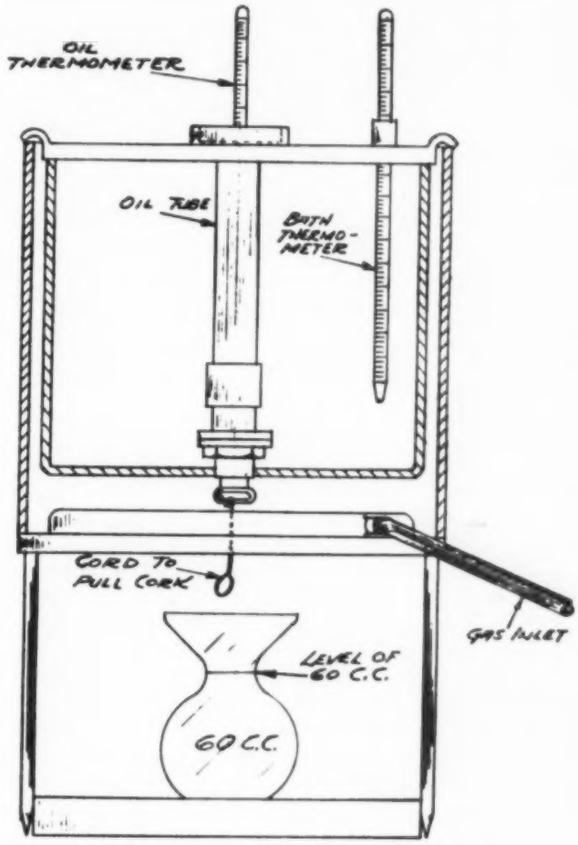
Practically all lubricants now used, both oils and greases, are either straight petroleum products or are compounded from petroleum products. Oils range from the light, non-viscous bodies on down to the heavy cylinder stocks. Greases likewise cover a wide range, including lime and soda soaps, aluminum stearate, lead base, and mixed base materials. To these lubricants must now be added the "EP" or extreme pressure lubricants, developed for heavy duty during the last few years.

Steel mill equipment frequently includes high speed units where oil lubrication is desirable. Ordinarily such equipment carries a comparatively light load, but the high speeds have a tendency to develop overheating unless light bodied oils are used. Sight feed, constant level, and wick feed oilers are commonly used on equipment of this nature, the last two being the most economical, although for certain types of equipment the accuracy and positive assurance of lubrication given by the sight feed system makes it preferable. With sight feed oiling systems, oils compounded with from ¼% to ½% of soaps adhere better to the bearing surfaces and feed more slowly, affording a degree of economy worth consideration. Recent work along this line has indicated that partially oxidized oils and certain of the newly developed chemically compounded oils have shown merit.

Circulating oil systems offer a number of advantages in lubricating gear drives and the bearings connected with them, cutting equipment, automatic machines, etc. Outstanding advantages of this system are:

1. Ample lubrication.
2. The circulation of the oil through the bearings has a cleansing action, washing out any foreign matter that might be present.
3. There is practically no churning of the lubricant in the bearing hence, with the minimum amount of lubricant present, lower operating temperatures are generally secured.
4. With a circulating system it is possible to provide for settling and filtering the lubricant. In case the lubricant has a tendency to become warm, it is possible to cool it separately, thus keeping the system supplied at all times with clean, cool lubricant.
5. The cooler operating conditions will reduce the oxidation or breaking down of the lubricant and thus increase its life.

Gears and anti-friction bearings are often lubricated with the same lubricant. In this case, a mineral oil that is satisfactory for the gears is usually entirely satisfactory for the anti-friction bearings. In quite a few cases, however, in order to take care of the gear units, it has been found necessary for good operation to use an extreme pressure lubricant of approximately 90 to 150 seconds viscosity at 210° F. Such a lubricant should carry a minimum load of 33 pounds on the Timken Lubricant Tester. The types of extreme pressure lubricants with which the Timken Company has had success on gear units are those having a lead soap sulphur base, a chlorinated sulphur base, and the straight chlorinated base compounds.

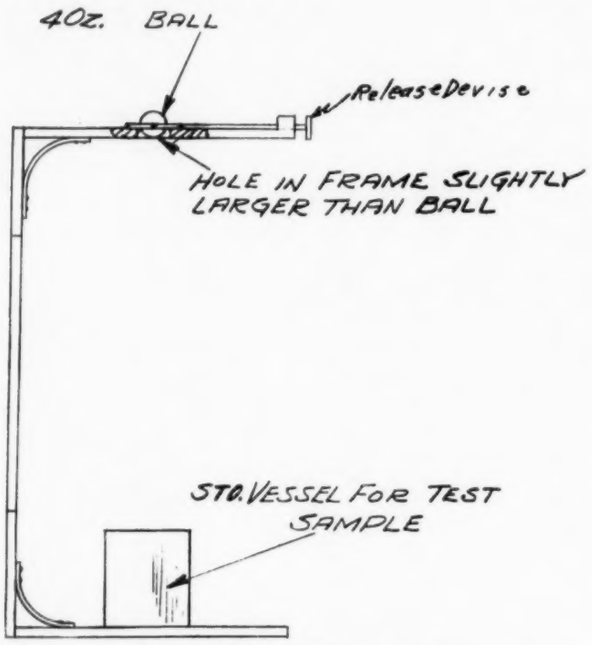


(Fig. 5)—Viscosity Test.

For table rolls, etc., encountered in mills, the type of lubricant is largely dependent on the design of the closures. If the closures are tight, fluid oils are entirely satisfactory and when this type of lubricant can be used this company prefers to recommend it.

Due to the design of equipment and the conditions under which it must operate, grease is now being widely used. Various types of greases are available and care should be exercised in their selection. Lime soap products are ordinarily lowest in price and have the widest use. As they are not particularly affected by water,

these greases as well as those compounded with aluminum stearate are widely used for lubricating equipment where moisture may be encountered and where operating speeds are comparatively low. High operating speeds and high temperature of operation usually calls for the use of soda soap lubricants since their melting point is higher.



(Fig. 6)—Karns-Maag Method Penetration Test.

In all cases where grease is used as a lubricant, it is essential for best results that ample space be provided in the housing, yet not so much room that the action of the bearing will throw the grease against the walls of the housing too far away for it to flow back readily to the bearing. Occasionally slow speed conditions will be encountered where it is essential that the housing be kept full of grease, but these are rare and require close watching. Normally, however, the housing should not be filled more than half full. This permits the grease to expand without being forced past the closures, avoids churning and insures adequate lubrication without waste.

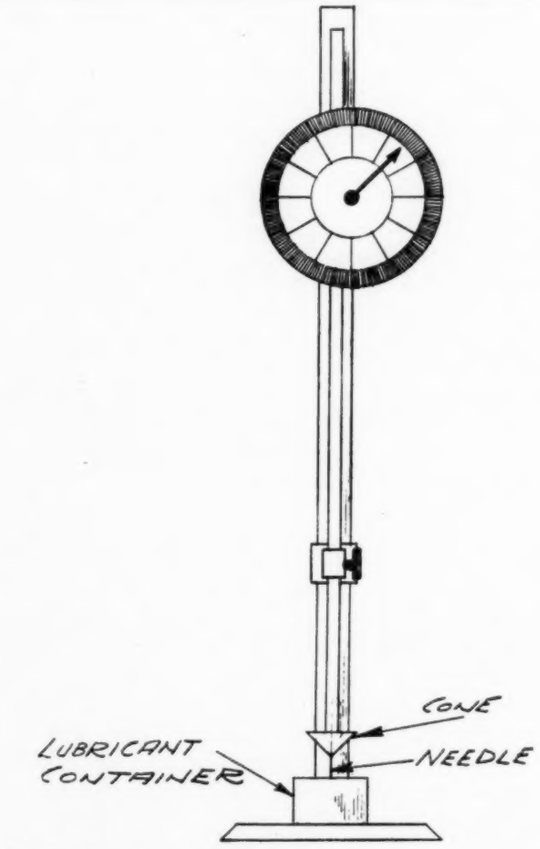
When applying grease to a bearing, particularly for the first time, care must be exercised to see that it is applied directly to the bearing and not merely placed in the housing. Provision should always be made so that over-zealous workmen cannot apply too much lubricant to anti-friction bearings in their routine greasing operations, for the reasons previously discussed.

There can be no question but that EP lubricants are here to stay, and it is practically safe to say that most greases of tomorrow will be of that type. Even though many mills now equipped with Timken Bearings are successfully using standard greases, the newer ones are using extreme pressure lubricants. Bearings of course must be designed with due regard for the type of lubricant to be used, for extreme pressure lubricants have in some cases a tendency to cause abrasion or corrosion unless proper precautions are taken. However, under present day operating conditions no one can tell when some mill operating condition will cause overloading, and consequently The Timken Rolling Bearing Company now recommends the use of extreme pressure lubricants for all types of bearings in steel mill heavy duty service. Good results are being obtained with lime-lead soap-sulphur products as well as the lime soap sulphurized base and the lead soap-sulphur-chloride base materials.

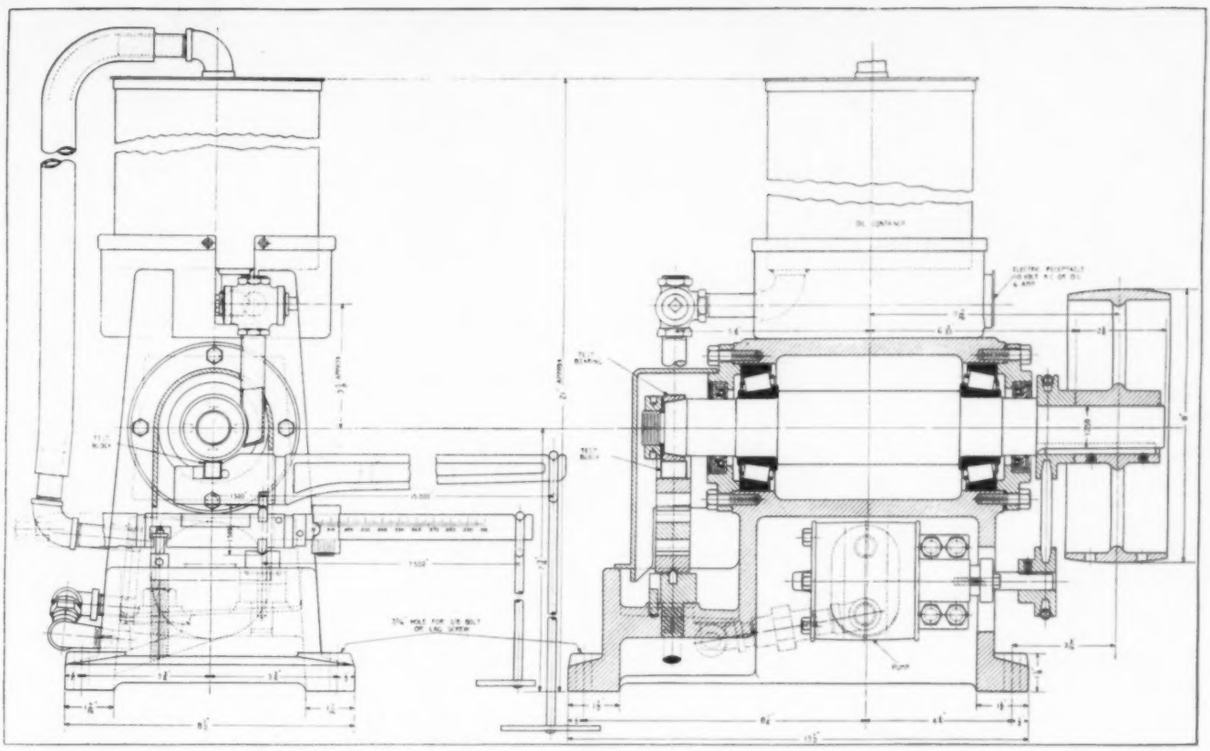
In the selection of a lubricant the bearing size, speed, temperature, load and general operating conditions must all be considered, with the most adverse conditions as the governing factor. For example, in applications using bearings not over 6 inches in outside diameter and operating at a speed of less than 1000 R.P.M. with no unusual service conditions, either a lime or soda soap grease of medium to medium soft consistency would be recommended. With the same set of conditions prevailing except that moisture is present, only a grease with a lime base would be satisfactory.

At speeds above 1000 R.P.M. oil is considered more satisfactory than grease, although on the smaller size bearings grease is successfully used. For bearings over 6 inches in outside diameter, medium consistency and medium to soft consistency greases are only recommended up to speeds of 500 R.P.M. Oil is considered as the better lubricant at speeds above 500 R.P.M.

Conditions of high temperature require special recommendations. A lime base grease will usually tend to



(Fig. 7)—Penetration Test.



(Fig. 8)—**Sections of Lubricant Tester Showing General Construction and Overall Dimensions.**

melt at approximately 150°-175° F. It therefore cannot be approved for higher temperatures. Soda base greases will usually hold up to over 200° F. and are therefore more suitable for the higher temperature applications. Above 200° F. better results are generally obtained with an oil having a viscosity of 100 to 200 seconds Saybolt Universal at 210° F. Steam cylinder oil of the proper degree of refinement for the requirements can be obtained from any reliable oil company.

Bearings exposed to extreme cold are best lubricated by an oil with a low viscosity and low cold test. A highly refined mineral oil with a viscosity of 75 to 500 seconds, Saybolt Universal, at 100° F. is recommended, depending upon the application. That is, the lighter bodied oils are used at high speeds and light loads and the heavier bodied oils at lower speeds and greater loads.

The following specifications for lubricants for general machinery and heavy duty applications, modified according to temperature and operating conditions as listed, have been developed by The Timken Roller Bearing Company and are recommended as a guide for selecting lubricants to be used in Timken Bearing applications:

SPECIFICATIONS—GENERAL MACHINERY APPLICATIONS

Grease should be compounded from a high grade soap and refined mineral oil, free from acid, alkali, and any filler which could act as a lapping agent. The consistency will vary with the temperature and operating conditions as outlined in the following tables.

Water Resistance: Lime base greases are recommended for conditions where moisture is present.

Corrosion: A bright copper or steel plate shall show no marked discoloration after being submerged in the grease for twenty-four hours.

Moisture: Maximum, 1 per cent.

Ash: Maximum, 2 per cent.

Separation: Grease should show no bleeding or separation either in storage or in use.

Another test for separation that might well be added is to heat the grease to 250° F. and allow it to cool, noting whether the grease comes back to a proper consistency and also how much oil will separate.

Oil from which grease is compounded shall conform to the following tests:

Flash: Minimum, 340° F.

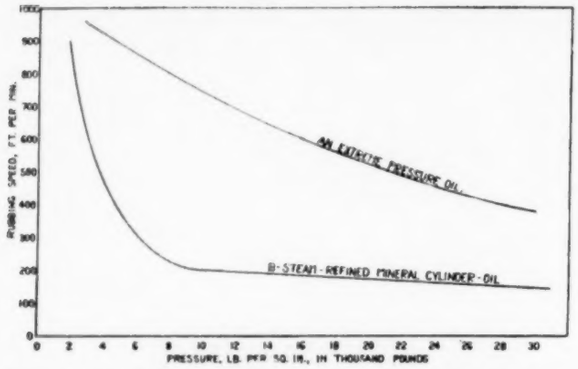
Fire: Minimum, 380° F.

Viscosity, Saybolt Universal, 200 seconds minimum at 100° F.

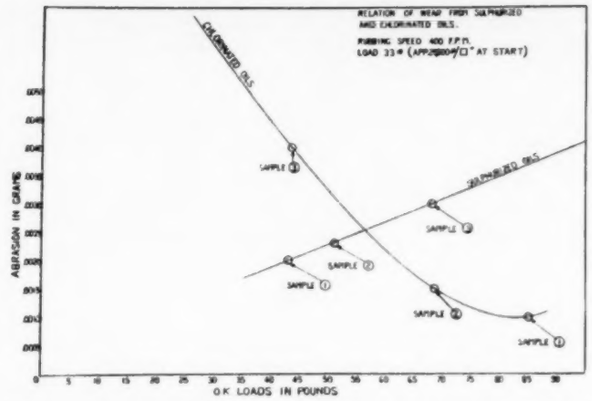
HEAVY DUTY APPLICATIONS

The specifications for lubricants for heavy duty applications and points where extreme pressures are present must follow the same general specifications as outlined for other greases. Grease must therefore be a well manufactured product, composed of a high grade soap and a refined mineral oil. It must be free from corrosive matter, grit, rosin, waxes, talc, mica, graphite, clay or fillers of any kind.

The consistency will depend upon the operating temperature. Definite recommendations are given in the accompanying table.


A: EXTREME PRESSURE OIL
B: STEAM-REFINED MINERAL CYLINDER-OIL
RUBBING SPEED, FT. PER MIN.
PRESSURE, LB. PER SQ. IN., IN THOUSAND POUNDS

(Fig. 9)—**Relation of Rubbing Speed to Pressure before Scuffing Starts or Excessive Abrasion Occurs.**



(Fig. 10)—**Relation of Wear from Sulphurized and Chlorinated Oils.**

Corrosion: A bright copper or steel plate shall show no marked discoloration after being submerged in the grease for fifty hours at normal bearing temperatures.

Water Resistance: It must function satisfactorily under all water conditions encountered.

Moisture: Maximum, 1 per cent.

The mineral oil from which the grease is compounded shall conform to the following tests:

Flash: Minimum, 375° F.

Fire: Minimum, 425° F.

Viscosity: Saybolt Universal, 75 seconds minimum at 210° F.

Cold Test, Pour: Maximum, plus 40° F.

The lubricant, when of the extreme pressure class, must prevent scoring on the Timken Lubricant Tester with a minimum load of 33 pounds on the lever arm at a minimum rubbing speed of 400 feet per minute.

In installations designed for oil lubrication, a refined oil of the above physical properties will usually be satisfactory for roller bearings. If a heavy bodied oil (steam refined cylinder oil with a viscosity of around 150 seconds at 210° F., Saybolt Universal) is desired for the pinions and gears, and it is desired to lubricate both roller bearings and gears with the same lubricant, the cylinder oil will usually be satisfactory for the roller bearings.

HEAVY DUTY APPLICATIONS

Operating Temperature	Moisture Present		No Moisture	
	Oil	Grease	Oil	Grease
Below 32° F.			Extreme Pressure Oil Viscosity 75 sec. to 100 sec. @ 210° F. Saybolt Universal. Load capacity minimum 33 lbs. lever load. Timken Lubricant Tester.	Extreme Pressure Grease; Lime or Soda Base. Consistency Karns-Maag Method 30.0 mm. to 45.0 mm. @ 75° F. Load capacity minimum 33 lbs. lever load. Timken Lubricant Tester.
32° F. to 125° F.	Extreme Pressure Oil Viscosity 100 sec. to 175 sec. @ 210° F. Saybolt Universal. Load capacity minimum 33 lbs. lever load. Timken Lubricant Tester.	Extreme Pressure, Water Resistant Grease. Consistency Karns-Maag Method 20.0 mm. to 30.0 mm. @ 75° F. Load capacity minimum 33 lbs. lever load. Timken Lubricant Tester.	Extreme Pressure Oil Viscosity 100 sec. to 175 sec. @ 210° F. Saybolt Universal. Load capacity minimum 33 lbs. lever load. Timken Lubricant Tester.	Extreme Pressure Grease; Lime or Soda Base. Consistency Karns-Maag Method 20.0 mm. to 30.0 mm. @ 75° F. Load capacity minimum 33 lbs. lever load. Timken Lubricant Tester.
125° F. to 180° F.	Extreme Pressure Oil Viscosity 100 sec. to 250 sec. @ 210° F. Saybolt Universal. Load capacity minimum 33 lbs. lever load. Timken Lubricant Tester.	Extreme Pressure, Water Resistant Grease. Consistency Karns-Maag Method 15.0 mm. to 25.0 mm. @ 75° F. Load capacity minimum 33 lbs. lever load. Timken Lubricant Tester.	Extreme Pressure Oil Viscosity 100 sec. to 250 sec. @ 210° F. Saybolt Universal. Load capacity minimum 33 lbs. lever load. Timken Lubricant Tester.	Extreme Pressure Grease; Lime or Soda Base. Consistency Karns-Maag Method 15.0 mm. to 25.0 mm. @ 75° F. Load capacity minimum 33 lbs. lever load. Timken Lubricant Tester.
Above 180° F.	Extreme Pressure Oil Viscosity 175 sec. to 250 sec. @ 210° F. Saybolt Universal. Load capacity minimum 33 lbs. lever load. Timken Lubricant Tester.	Not Recommended.	Extreme Pressure Oil Viscosity 175 sec. to 250 sec. @ 210° F. Saybolt Universal. Load capacity minimum 33 lbs. lever load. Timken Lubricant Tester.	Not Recommended.

TABLE III

Type and Viscosity of Lubricants Recommended for Timken Bearings in General Machinery Applications.

Speed—Up to 500 R.P.M.

Operating Temperature	Bearing Size	Moisture Present		No Moisture	
		Oil	Grease	Oil	Grease
Below 32° F.	Up to 6″ O.D.			Neutral Mineral; Viscosity 75 sec. to 500 sec. @ 100° F. Saybolt Universal.	Lime or Soda Base; Consistency 20.0 mm. to 50.0 mm. @ 75° F. Karns-Maag Method.
	6″ O.D. and above			Neutral Mineral; Viscosity 75 sec. to 500 sec. @ 100° F. Saybolt Universal.	Lime or Soda Base; Consistency 20.0 mm. to 50.0 mm. @ 75° F. Karns-Maag Method.
32° F. to 125° F.	Up to 6″ O.D.	Neutral Mineral; Viscosity 100 sec. to 700 sec. @ 100° F. Saybolt Universal.	Lime Base; Medium Consistency 20.0 mm. to 40.0 mm. @ 75° F. Karns-Maag Method.	Neutral Mineral; Viscosity 100 sec. to 700 sec. @ 100° F. Saybolt Universal.	Lime or Soda Base; Medium Consistency 20.0 mm. to 40.0 mm. @ 75° F. Karns-Maag Method.
	6″ O.D. and above	Neutral Mineral; Viscosity 100 sec. to 700 sec. @ 100° F. Saybolt Universal.	Lime Base; Medium Consistency 20.0 mm. to 40.0 mm. @ 75° F. Karns-Maag Method.	Neutral Mineral; Viscosity 100 sec. to 700 sec. @ 100° F. Saybolt Universal.	Lime or Soda Base; Medium Consistency 20.0 mm. to 40.0 mm. @ 75° F. Karns-Maag Method.
125° F. to 180° F.	Up to 6″ O.D.	Neutral Mineral; Viscosity 60 sec. to 100 sec. @ 210° F. Saybolt Universal.	Lime Base; Medium Consistency 15.0 mm. to 30.0 mm. @ 75° F. Karns-Maag Method.	Neutral Mineral; Viscosity 60 sec. to 100 sec. @ 210° F. Saybolt Universal.	Soda Base; Medium Consistency 15.0 mm. to 30.0 mm. @ 75° F. Karns-Maag Method.
	6″ O.D. and above	Neutral Mineral; Viscosity 60 sec. to 100 sec. @ 210° F. Saybolt Universal.	Lime Base; Medium Consistency 15.0 mm. to 30.0 mm. @ 75° F. Karns-Maag Method.	Neutral Mineral; Viscosity 60 sec. to 100 sec. @ 210° F. Saybolt Universal.	Soda Base; Medium Consistency 15.0 mm. to 30.0 mm. @ 75° F. Karns-Maag Method.
Above 180°	Up to 6″ O.D.	*Neutral Mineral; Viscosity 100 sec. and up @ 210° F. Saybolt Universal.	Not Recommended.	*Neutral Mineral; Viscosity 100 sec. and up @ 210° F. Saybolt Universal.	Not Recommended.
	6″ O.D. and above	*Neutral Mineral; Viscosity 100 sec. and up @ 210° F. Saybolt Universal.	Not Recommended.	*Neutral Mineral; Viscosity 100 sec. and up @ 210° F. Saybolt Universal.	Not Recommended.

*Refined cylinder oil meeting these specifications may be obtained from most companies.

Speed—500 to 1000 R.P.M.

Below 32° F.	Up to 6″ O.D.			Neutral Mineral; Viscosity 75 sec. to 500 sec. @ 100° F. Saybolt Universal.	Lime or Soda Base; Consistency 20.0 mm. to 50.0 mm. @ 75° F. Karns-Maag Method.
	6″ O.D. and above			Neutral Mineral; Viscosity 75 sec. to 500 sec. @ 100° F. Saybolt Universal.	Not Recommended.
32° F. to 125° F.	Up to 6″ O.D.	Neutral Mineral; Viscosity 100 sec. to 700 sec. @ 100° F. Saybolt Universal.	Lime Base; Medium Consistency 20.0 mm. to 40.0 mm. @ 75° F. Karns-Maag Method.	Neutral Mineral; Viscosity 100 sec. to 700 sec. @ 100° F. Saybolt Universal.	Lime or Soda Base; Medium Consistency 20.0 mm. to 40.0 mm. @ 75° F. Karns-Maag Method.
	6″ O.D. and above	Neutral Mineral; Viscosity 100 sec. to 700 sec. @ 100° F. Saybolt Universal.	Not Recommended.	Neutral Mineral; Viscosity 100 sec. to 700 sec. @ 100° F. Saybolt Universal.	Not Recommended.
125° F. to 180° F.	Up to 6″ O.D.	Neutral Mineral; Viscosity 60 sec. to 100 sec. @ 210° F. Saybolt Universal.	Lime Base; Medium Consistency 15.0 mm. to 30.0 mm. @ 75° F. Karns-Maag Method.	Neutral Mineral; Viscosity 60 sec. to 100 sec. @ 210° F. Saybolt Universal.	Soda Base; Medium Consistency 15.0 mm. to 30.0 mm. @ 75° F. Karns-Maag Method.
	6″ O.D. and above	Neutral Mineral; Viscosity 60 sec. to 100 sec. @ 210° F. Saybolt Universal.	Not Recommended.	Neutral Mineral; Viscosity 60 sec. to 100 sec. @ 210° F. Saybolt Universal.	Not Recommended.
Above 180° F.	Up to 6″ O.D.	*Neutral Mineral; Viscosity 100 sec. and up @ 210° F. Saybolt Universal.	Not Recommended.	*Neutral Mineral; Viscosity 100 sec. and up @ 210° F. Saybolt Universal.	Not Recommended.
	6″ O.D. and above	*Neutral Mineral; Viscosity 100 sec. and up @ 210° F. Saybolt Universal.	Not Recommended.	*Neutral Mineral; Viscosity 100 sec. and up @ 210° F. Saybolt Universal.	Not Recommended.

*Refined cylinder oil meeting these specifications may be obtained from most companies.

TABLE III (CONT'D.)
Speed—Over 1000 R.P.M.

Operating Temperature	Bearing Size	Moisture Present		No Moisture	
		Oil	Grease	Oil	Grease
Below 32° F.	Up to 6″ O.D.			Neutral Mineral; Viscosity 75 sec. to 300 sec. @ 100° F. Saybolt Universal.	Soda Base; Short Fibre, Consistency 30.0 mm. to 50.0 mm. @ 75° F. Karns-Maag Method.
	6″ O.D. and above			Neutral Mineral; Viscosity; 75 sec. to 300 sec. @ 100° F. Saybolt Universal.	Not Recommended.
32° F. to 125° F.	Up to 6″ O.D.	Neutral Mineral; Viscosity 100 sec. to 700 sec. @ 100° F. Saybolt Universal.	Lime Base; Medium Consistency 20.0 mm. to 40.0 mm. @ 75° F. Karns-Maag Method.	Neutral Mineral; Viscosity 100 sec. to 700 sec. @ 100° F. Saybolt Universal.	Soda Base; Medium Consistency 20.0 mm. to 40.0 mm. @ 75° F. Karns-Maag Method.
	6″ O.D. and above	Neutral Mineral; Viscosity 100 sec. to 700 sec. @ 100° F. Saybolt Universal.	Not Recommended.	Neutral Mineral; Viscosity 100 sec. to 700 sec. @ 100° F. Saybolt Universal.	Not Recommended.
125° F. to 180° F.	Up to 6″ O.D.	Neutral Mineral; Viscosity 60 sec. to 100 sec. @ 210° F. Saybolt Universal.	Lime Base; Medium Consistency 15.0 mm. to 30.0 mm. @ 75° F. Karns-Maag Method.	Neutral Mineral; Viscosity 60 sec. to 100 sec. @ 210° F. Saybolt Universal.	Soda Base; Medium Consistency 15.0 mm. to 30.0 mm. @ 75° F. Karns-Maag Method.
	6″ O.D. and above	Neutral Mineral; Viscosity 60 sec. to 100 sec. @ 210° F. Saybolt Universal.	Not Recommended.	Neutral Mineral; Viscosity 60 sec. to 100 sec. @ 210° F. Saybolt Universal.	Not Recommended.
Above 180° F.	Up to 6″ O.D.	*Neutral Mineral; Viscosity 100 sec. and up @ 210° F. Saybolt Universal.	Not Recommended.	*Neutral Mineral; Viscosity 100 sec. and up @ 210° F. Saybolt Universal.	Not Recommended.
	6″ O.D. and above	*Neutral Mineral; Viscosity 100 sec. and up @ 210° F. Saybolt Universal.	Not Recommended.	*Neutral Mineral; Viscosity 100 sec. and up @ 210° F. Saybolt Universal.	Not Recommended.

*Refined cylinder oil meeting these specifications may be obtained from most companies.

STEEL MILL LIGHTING

DEVELOPMENTS MADE DURING 1935

By D. H. TUCK, Electrical Engineer
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▲ ONE of the outstanding developments in lighting applicable to iron and steel mills this year is the 400 watt high intensity mercury lamp and the reflector equipment that has been made for it. The lamp is rated at 400 watts—220 volts, 60 cycle (only), 16,000 lumens, (750 watt Mazda lamp 14,550 lumens for comparison) life 2000 hours, mogul base, T-16 bulb 13″ overall length—2″ diameter, length of light source 6⅛″, light center 7¾″, made for either base up or base down burning (specify which). A reactor must be placed in series with each lamp—its location with respect to its proximity to the lamp is immaterial. When 220 volt supply is not available an autotransformer reactor is used with 115 volts. The power factor of the reactor or reactor transformer is 60-65%. A high power factor reactor or reactor transformer with condenser giving a 90-95% power factor is also available. The lamp requires approximately 7 minutes to come up to full lumen output. When the energy supply is momentarily interrupted the lamp is extinguished. Before relighting it must cool which requires approximately 7 minutes for a well ventilated reflector—longer for others.

New reflector equipment has been designed for the mercury lamp for high bays, low bays, angle type and indirect office equipment. The mercury unit is indicated for chipping, tin plate inspection, stainless steel finishing, machine shops and generally for use in high

Interior view of Ford Steel Plant, Fordson, Mich.

bays. The mercury lamp is advantageous because of economic reasons or because of the desirability of the characteristic yellow green mercury color. The admixture of Mazda lamps in part destroys both advantages. When Mazda lamps are used in part to give some illumination in case of momentary voltage failure they should be on a current relay so that they come on when the mercury lamps fail and go off when the mercury lamps come up to approximate lumen output. The largest installation to date is the new sheet mill of the Youngstown Sheet & Tube Co. at Youngstown where approximately 600 units have been in service for about six months. Based on equal illumination it can be shown that, from an economy standpoint, a saving can be made when current cost is greater than 7 mills per kw hr. The first cost of the equipment per outlet (based on equal illumination) is greater for the mercury lamp than the Mazda lamp by approximately 62%—allow $34.00 per outlet exclusive of wiring.

The illumination in foot candles cannot be read by a photronic cell lightmeter without applying a connection factor as these meters have been calibrated of Mazda lamps. Special meters are available for making measurements of mercury illumination.

In general reflector equipment for mercury lamps is less efficient than that for Mazda lamps although there is reflector equipment now available whose efficiency is equal to those made for Mazda lamps.

The illumination intensities used in good practice in new mills is substantially the same as for the past five years.

Location	Footcandles
Open Hearth Charging	10
Open Hearth Pouring Off	5
Chipping	30
Machine Shop	30
Billet Mill	10
Cold Sheet	15
Hot Sheet	10
Cold Strip	15
Hot Strip	10
Rod Mill	10
Bar Mill	15
Precision Bar Mill	20
Merchant Mill	10
Blooming Mill	5
Galvanizing Wire	5
Tin Plate Inspection	25
Stainless Steel Finishing	25
General Office	15
Drafting Room	30

Steel covered glass reflectors of both the prismatic and mirrored types for high and low bays are in general use. The steel covered units have been developed within the last year. The purpose of the steel cover is SAFETY. When the steel cover is spun onto the glass reflector no glass will fall if the glass is accidently broken. This safety feature does not apply to all steel covered glass reflectors.

Interior view of Ford Steel Plant, Fordson, Mich.

A special unit for use in first aid rooms has been developed that gives a general indirect illumination of 10-foot candles and by opening a diaphragm a direct illumination of 100 foot candles is focused on the operating table. This unit is low in price and especially useful for treating cuts, burns, foreign body in eye and other ordinary mill cases.

For drafting room lighting an indirect mercury unit is available either with the 400 watt mercury unit alone or in combination with Mazda lamps. The necessary 30 foot candles can be secured by spacing the mercury units on 12′ centers and the combination units on 17′ centers.

A local lighting unit for machine shop use has been developed. This unit uses a standard 100 watt lamp and concentrates the light on the work to produce 100 foot candles without glare.

A new inspection unit for laboratory use has been made that has color correction to approximate daylight in color. Two types are available. The concentrating unit delivers 100 foot candles over a small area and the spread unit delivers 50 foot candles over a long narrow table—150 watt clear lamps are used.

New obstruction lights have been developed for an aid to aerial navigation to meet the Dept. of Commerce, June 1935 requirements for lighting transmission towers, chimneys, water tanks and other obstructions.

STEEL MELTING FURNACES

AUTOMATIC CONTROL IN THE OPEN HEARTH

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▲ THE various regulating functions which, together, make up what is known as automatic control of the open hearth furnace, are, by this time well understood by steel makers and furnace designers, who have also become generally familiar with the equipment employed for these purposes. The ability to perform the acts of regulation accurately and without interruption is usually taken for granted, and interest centers in a study of the results obtainable by these means. Test runs have been made at several places with and without regulating equipment and the results noted. So far as the writer knows, these tests have in every case shown a decrease in fuel consumption ranging from seven to eleven percent and a notable increase in rate of production. From the standpoint of a prospective purchaser such tests are the most immediately conclusive evidence of the value of control, and it is reasonable that such a purchaser should require such a result. To those more closely connected with open hearth operation or design, a detailed knowledge of the results of control is necessary. Overall practice figures can never be compared in terms of one variable in an operation so complicated as that of the open hearth, and control equipment is usually installed along with other changes in construction and practice, so that it might be possible in the view of several observers, to credit improvement to insulation, modification of regenerators, change in the charge, in the fuel or the steel specifications, or to control, as dictated by the judgment or interest of the individual.

It is possible, however, to analyze the effects of stabilizing each of the conditions which are governed by automatic control, and in some degree to evaluate them. A brief attempt at such an analysis follows.

In the writer's opinion, control practiced in the name either of fuel economy or accurate processing, should begin with regulation of the rate of fuel feed in terms of standard units of volume. Means are now completely developed whereby the flow of fuel gas or gases may be definitely set and handled by the control. The result is a program of fuel use by the operator. This program may be modified in accordance with variations in the fuel itself or in the charge. The simplest form of flow control is one which is manually set in accordance with an indicating scale which forms part of the regulator. Such a control device is nominally the same in effect as the setting of a valve in a fuel line in which an upstream pressure is maintained, the setting being done in accordance with a meter reading. Actually, it has been found that the flow regulator with setting indicator is not only more convenient and accurate, but that it leads to a practical estimation of fuel requirement by the operator, not usually made. The practice of yesterday is memorized in figures and improvement is made by close reference to the detail of past experience.

A variation of flow control is one in which the flow of fuel is limited by the temperature of the open hearth roof. This device is to be distinguished from those which cut the fuel off completely when the roof becomes too hot. It is a flow control manually adjusted for any desired flow but provided with means whereby the fuel is automatically reduced below that called for by the manual setting, the reduction being just sufficient to avoid overheating the roof. This device is technically well developed and accurate, and subject only to the criticism that metering of temperature at one point is not completely satisfactory in its ability to protect an entire roof. Multiple observations of roof temperature and their use in mechanical rotation is a

A. J. BOYNTON

feasible means of meeting this objection. The value of roof temperature control has been less thoroughly demonstrated than is the case with other regulating acts, since it has been more recently developed.

Control of furnace pressure is now universally conceded to be very desirable, and its rapid application to all operating furnaces may be expected. Aside from the well known function of reducing or preventing infiltration of unregenerated air, the pressure control in reality acts as a control of the rate of flow of exit gases, bringing this flow into exact equality with the rate of gas formation. The result, with an accurate control, is a steady maintenance of the shape and length and, in some degree, the height of the flame, and the avoidance of impingement of hot gases on the furnace walls at the wrong place.

The feature of open hearth control which has been least generally applied in proportion to the benefits which, in the writer's opinion, are possible to derive from it is the control of combustion air in relation to fuel. This is a comparatively expensive item of control, on account of the necessity of installing fan, motor, and piping in which metering devices both for fuel and for air may be located, as well as the control itself. The former permeability by air of the whole open hearth furnace system operated to prevent any close regulation of combustion air by practicable methods until recently.

Present day furnaces are so nearly tight that regulation of combustion air may be accurately done. Two general methods have been employed, one a regulation of air in accordance with the percentage of oxygen in the exit gases and the other a volumetric proportioning of air to gas. The former method is attractive in principle, and viewed as a solution of a problem in automatic control, is academically correct. It is much more difficult to carry out accurately than is the proportioning method, and is subject to objections on account of stratification of gases and lag, the latter resulting in the dealing by the control with a condition which may have ceased to exist. Proportioning regulation, with an air tight system is capable of giving results which are entirely satisfactory as to accuracy. Such a regulator should usually be equipped with a panel board on which are mounted means for making adjustments in accordance with temperatures of air and gas, as they come to the furnace system. The operator is merely required to look at a thermometer reading air temperature and another for gas, say, once an hour, and set his dial on the panel for the correction, if any. Adjustment on account of any and all variables, including allowance for estimated percentage of leakage, may easily be set, and the regulator is then the most accurate known apparatus for proportioning air to fuel, with easy means of changing the proportions, as is required several times during an open hearth heat.

The results of such proportioning are in some degree a matter of differing opinions. Some people have attempted to calculate a difference in temperature due to avoidance of excess air. All figures on which such calculations are based presuppose instantaneous combustion, absorption of generated heat into the products and no radiation. None of these conditions are fulfilled in the open hearth. The construction of the ports contemplate a long flame and a gradual mixture of air with gas. Under these circumstances, excess air is not primarily serious, and expectations of immediately higher temperatures due to its elimination, are sure to be disappointed. Practical realization of this fact by open hearth people has delayed the adoption of combustion control.

There are, however, two features of air control, which, as furnaces and furnace practice improve, make it well worth adopting. The first of these is the ability to put the same amount of air into both ends of the furnace, and to put the same amount into the same end after each reversal, without continual adjustment by the crew. Ability to maintain a desired rate of operation, even with dirty checkers is another result of a metered and forced air supply. This uniformity is conducive to rapid action, while at the same time, injury to the furnace is avoided.

The second advantage is found, where the control is seriously used as a means of avoiding excess air, in the smaller volume of exit gases, their higher temperature, and the lessened carry-over of solids. This carry-over presumably varies as the square of the gas velocity, so that a comparatively small reduction in the speed of gases may greatly reduce the carry-over. All of these results lead to improved service by the furnace regenerators both as to immediate results and as to time in use. The combination of furnace pressure and air-gas ratio control has an effect which is worth more than twice as much as either singly, since they react on each other.

Other features of control by means of which the furnace is automatically reversed, in accordance with a temperature cycle have played a useful part. One benefit of such an installation is to call attention to lack of balance between the two ends of the furnace, a condition which metering and controlling of air and gas into the furnace will, in considerable measure, correct.

It cannot be too often repeated or too greatly emphasized that control equipment is a tool, whereby conditions are stabilized, and that the benefit derived is in proportion to the intelligence, interest and care of the operators. Stabilizing an undesirable condition is of little benefit. On the other hand, the ability to stabilize leads to more and more complete acquaintance with what conditions are correct. Continued interaction between good control equipment and an intelligent operating force may be relied on to produce results much better than those possible without the continuous and unwearying assistance of the controls.

KEEP MOVING

By M. J. CONWAY, Fuel Engineer
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▲ TRANSPORTATION and its contributing industries, railroads, automobiles, ships, oil and gas, mining, highway bridges, account for more than 50 per cent of the steel tonnage produced. Modes of transportation have been recognized through the ages as essential to cultural development, economic progress, and the growth of civilization.

The foremost thought with regard to transportation is, and will continue to be, to provide sufficient means for the mass movement of commodities and people, rapidly, comfortably, safely, and economically into and out of centers of population and from one center to another. In this the railroad has not failed us and is the most adequate rapid and satisfactory means yet devised for accomplishing our mass transportation needs, so much so, that it would be sad to contemplate what would happen in the form of economic loss and inconvenience, that would arise from the stoppage of the railroads for just one week.

Then there are some who say that the railroads are on the way out. Everything that has happened in transportation for thousands of years has taken place in the last one hundred years—Peter Cooper designed and constructed the first locomotive in this country in 1829—and almost the same yardstick can be applied to all forms of creative and productive endeavor in the material world. We are still on the threshold of scientific and technical developments that will put into the hands of man, power that he dare not dream about.

Scrapping of a few obsolete inter-urban street car lines does not mean that the railroads are done, that they are blind to the developments of science and engineering, and that they are unconscious of, and unconcerned about the requirements and trends of this period. While it is true that the freight trucking industry has grown apace during the past ten years, and it has a definite useful place in our civilization, in the total scheme of things it will never be a serious competitor to the railroads. However, it is true that there is a certian amount of truck competition but of the 640,000,000 tons of freight lost during the past six years only 4 per cent can be attributed to truck competition, the other 96 per cent was not there to move due to general business conditions.

This naturally has affected buying, as loss of revenue always does, because over half of all rail revenue is absorbed by wages and taxes which represents two-thirds of total operating expenses—over which management has no control—so, therefore, purchases are cut to the minimum. While on the subject of taxes it may be fair to state that twenty of the leading railroads in the country contributed over two and one quarter billion dollars in taxes during the past ten years. Cost of operation is constantly improving, the average cost per 1000 revenue ton miles of freight traffic in 1920 was $10.66, whereas in 1933 it was $6.48. Few industries can show such operating improvement in face of depression difficulties. And in safety the railroads do not have to take a back seat. A study of comparable statistics is interesting and important. On the highways there is one fatality for each 20,000,000 passenger miles. On the airways, there is one fatality for each 24,000,000 passenger miles, while on the railroads, there is one fatality for each 400,000,000 passenger miles. For the 8.6 billion passenger miles travelled during the first six months of 1935, there was not a single passenger killed in a train accident. So from a safety standpoint, railroads are not on their way out.

One fallacy that has raised its head during the late depression is that we were over-produced and that the country was finished, with the last frontier passed. We had built all the roads, cities, water works, light plants and what not and from now on it is an operating and maintenance proposition and that is all. But this is as stated—a fallacy. We are but one step removed from camping out in much of this country; we are still so far away from having a widespread enjoyment of the standards of living that are quite within reach that we have lots of work yet to do in building our cities and equipping them, in building our highways and other agencies of transportation and communication and in applying to the service of men, power, materials, and conveniences that we have not yet imagined. All of which contributes to more material handling, more transportation.

While much remains to be done, the railroads air conditioned 5000 cars during the past three years, an expenditure of $40,000,000 for passenger comfort, and research and engineering development goes on apace, dealing with alloys, fabrics, plastics, insulation materials for temperature and noise, air conditioning, stream lining, riding qualities, etc. Advances in motive power design have been notable during the past two years and improvement has been constantly taking place during the past decade. The average running speed of the locomotive was 42 miles per hour in 1930 as compared with 26 miles in 1910. The draw bar horse power of the 1930 locomotive was 3590 as compared with 1240 of the 1910 variety. The per cent of decrease in fuel per draw bar horse power per hour was 40% less in 1930 than in 1910.

Comparing the railroads with their so-called truck competitor, they average 5000 ton miles per man hour compared with 100 ton miles per man hour in the freight trucking industry, all of which contributes to the fundamental reasons why the railroads have and will continue to provide the safest, most adequate, and economic means of mass transportation.

Passenger revenues continue to steadily improve in spite of the fact that we have just completed a 4,000,000 new car year; and with taxes in excess of $38.00 per car for America's 25,000,000 car owners, the railroads will have a competitive chance to hold their own for a few more decades. All in all, those who travel use steel. Let's keep moving-ahead.

REHABILITATION AND MODERNIZATION

IN THE IRON AND STEEL INDUSTRY DURING 1935

▲ OF THE ESTIMATED $150,000,000 expended in the industry for new steel producing equipment during the past year, fully 85% of this amount was allocated to the rolling and finishing departments. Of outstanding interest during this period were the 31 hot and cold rolling mill units, that were completed, under construction or authorized, designed to accommodate 7,000,000 gross tons of flat rolled steel annually.

COKE OVENS

Five batteries or 293 by-product coke ovens with an annual coking capacity of 775,000 tons were completed or under construction at the close of the year. The Ford Motor Company installed two batteries of sixty-one ovens each at Detroit, Michigan; the Carnegie-Illinois Steel Corporation rebuilt two batteries of sixty-four ovens each at Gary, Indiana, and the Columbia Steel Corporation rebuilt a battery of thirty-three ovens at its Provo, Utah, plant.

BLAST FURNACES

No new blast furnaces were installed during the past year and all expenditures for equipment to improve present stacks in operation were minor. Three operators are rebuilding stacks at present, one each at the Carnegie-Illinois Steel Corporation's plant at Braddock, Penna., Youngstown Sheet & Tube Company at the Campbell Ohio works, and the Bethlehem Steel Company at the Sparrows Point, Maryland, plant.

The Carnegie-Illinois Steel Corporation blew-in two inactive furnaces for producing merchant pig iron solely, at the Central Furnace plant in Cleveland, formerly owned and operated by the American Steel & Wire Company.

OPEN HEARTHS

No additional open hearth melting capacity was added during 1935. In the latter part of December, the Great Lakes Steel Corporation at Ecorse, Michigan, authorized the construction of four 150-ton furnaces to be completed in 1936, increasing this plant's annual ingot output 125,000 tons.

The improved operating tonnage rate of the industry over the past twelve months permitted quite liberal expenditures for equipment to produce better steel at lower cost. Appropriations granted for new equipment were largely confined to the purchase of combustion control apparatus, improved ports, temperature control apparatus, insulation and refractories.

ROLLING MILLS

Blooming and Slabbing Mills

One new blooming mill was purchased, one existing mill was revamped, and an order was placed with a mill builder for a slabbing mill.

All of the above units are being designed ostensibly to supply semi-finished steel to flat rolling units.

The Jones & Laughlin Steel Corporation is, at present, installing a 44″ two-high reversing blooming mill at their South Side works in Pittsburgh for furnishing blooms and slabs to their contemplated broad strip mill.

Inland Steel Company, Indiana Harbor, Indiana, rebuilt their 36″ blooming mill and have purchased a 44″ reversing slabbing mill. The product of this unit will be slabs of suitable width for the 79″ continuous hot mill and will eliminate heavy drafts on the spreading stand.

HOT STRIP MILLS

The year 1935, no doubt, witnessed the peak in the construction of the hot continuous broad strip mills. This year saw four units of this type placed in operation; one existing mill was revamped, and the other three were new projects. At the close of 1934, four mills were on order, one existing mill is being revamped, and the authorization for three more contemplated mills is expected to be granted before March 1, 1936.

Hot strip mills which began initial operation were the 38″ revamped mill of the Carnegie-Illinois Steel Corporation, at Gary, Indiana, the 54″ mill of the Ford Motor Company at Detroit, Michigan, the 79″ mill of the Youngstown Sheet & Tube Company, Youngstown, Ohio, the 79″ mill of the Bethlehem Steel Company at Lackawanna, New York and the 42″ mill of the Carnegie-Illinois Steel Corp. at McDonald, Ohio.

The following tables contain the capacities of the mills completed and under construction at the close of the year:

Mills under construction are the 84″ mill of the American Sheet & Tin Plate Company at Gary, Indiana, the 79″ mill of the Great Lakes Steel Corporation at Ecorse, Michigan, the 84″ mill at the Granite City Steel Company, Granite City, Illinois, and the 100″ plate mill of the Carnegie-Illinois Steel Corporation at Homestead, Penna.

The Jones & Laughlin Steel Corporation is planning an expansion program which will include a wide strip and sheet mill with the complementary cold reduction equipment.

HOT STRIP MILLS AND CAPACITIES COMPLETED DURING 1935

Company	Location	Size	Annual Capacity
Carnegie-Illinois Steel Corp.	Gary, Ind.	38″ (revamped)	300,000
Carnegie-Illinois Steel Corp.	McDonald, O.	42″	360,000
Youngstown Sheet & Tube Co.	Youngstown, O.	79″	600,000
Bethlehem Steel Company	Lackawanna, N. Y.	79″	600,000
Ford Motor Company	Detroit, Mich.	54″	480,000

HOT STRIP MILLS TO BE COMPLETED DURING 1936

American Sheet & Tin Plate Co.	Gary, Ind.	84″	600,000
Carnegie-Illinois Steel Corp.	Homestead, Pa.	100″	720,000
Granite City Steel Co.	Granite City, Ill.	84″	400,000
Jones & Laughlin Steel Corp.	Pittsburgh, Pa.	....	700,000
Great Lakes Steel Corp.	Ecorse, Mich.	79″	800,000

COLD STRIP MILLS

All the hot strip mills placed in operation or under construction during the past year are supplemented by units for cold rolling, with but two exceptions.

The products of the Carnegie-Illinois Steel Corporation's 42″ mill at McDonald, Ohio, and the 38″ mill at Gary, Indiana, will be limited to hot rolled strip in cut lengths or coils.

The electrical and mechanical characteristics of representative cold strip mill installations, as well as their capacities, are given elsewhere in this issue of the Iron and Steel Engineer.

ELECTRICAL AND MECHANICAL CHARACTERISTICS OF STEEL ROLLING MILLS COMPLETED OR UNDER CONSTRUCTION DECEMBER 31, 1935

AMERICAN SHEET & TIN PLATE COMPANY, GARY, INDIANA

HOT STRIP MILL
Estimated Annual Capacity—600,000 Tons

Motor				ROLL DATA			No. of	Method
HP	Speed	Voltage	Current	Dia.	Length	Type	Stands	of Drive
1250	514	6600	60	36″	80″	Sc. Br.	1	Geared
3500	360	6600	60	40″–54″	130″	4-High Spreader	1	Geared
350	400–800	230	DC			Edger	1	Geared
3500	514	6600	60	26″–53″	80″	4-High	1	Geared
350	400–800	230	DC			Edger	1	Geared
3500	514	6600	60	26″–53″	80″	4-High	1	Geared
350	400–800	230	DC			Edger	1	Geared
3500	514	6600	60	26″–53″	80″	4-High	1	Geared
800	150–450	600	DC	36″	80″	Sc. Br.	1	Geared
4500	85–190	600	DC	26″–53″	80″	4-High	1	Dir. Coupl.
4500	100–230	600	DC	26″–53″	80″	4-High	1	Dir. Coupl.
4500	125–282	600	DC	26″–53″	80″	4-High	1	Dir. Coupl.
4500	125–282	600	DC	26″–53″	80″	4-High	1	Dir. Coupl.
4500	125–282	600	DC	26″–53″	80″	4-High	1	Dir. Coupl.
3000	100–255	600	DC	26″–53″	80″	4-High	1	Direct

BETHLEHEM STEEL COMPANY, LACKAWANNA, N. Y.

HOT STRIP MILL
Estimated Annual Capacity—600,000 Tons

Motor				ROLL DATA			No. of	Method
HP	Speed	Voltage	Current	Dia.	Length	Type	Stands	of Drive
1000	375	6600	25			Sc. Br.	1	Geared
3000	150	6600	25	36″–49″	96″	A—High Spreader	1	Direct
150	450–900	600	DC			Vert. Edger		Geared
3000	500	6600	25	25″–49″	79″	4-High	1	Geared
150	450–900	600	DC			Vert. Edger		Geared
3000	500	6600	25	25″–49″	79″	4-High	1	Geared
150	450–900	600	DC			Vert. Edger		Geared
3000	514	6600	25	25″–49″	79″	4-High	1	Geared
500	150–600	600	DC			Sc. Br.		Geared
4500	125–250	600	DC	25″–49″	79″	4-High	1	Geared
4500	125–250	600	DC	25″–49″	79″	4-High	1	Geared
3500	175–350	600	DC	25″–49″	79″	4-High	1	Geared
3500	175–350	600	DC	25″–49″	79″	4-High	1	Geared
3500	175–350	600	DC	25″–49″	79″	4-High	1	Geared
2500	175–350	600	DC	25″–49″	79″	4-High	1	Geared

MOTOR GENERATOR DATA

	KVA	KW	Voltage	Speed	Freq.	PF
AC Motors	1–5800		6600	500	25	1.0
	2–6600		6600	375	25	.8
DC Generators		2–2000	600	500	DC	
		2–3000	600	375	DC	

CARNEGIE-ILLINOIS STEEL CORPORATION, HOMESTEAD, PA.

HOT PLATE STRIP MILL
Estimated Annual Capacity—728,900 Tons

Motor HP	Speed	Voltage	Current	ROLL DATA Dia.	ROLL DATA Length	Type	No. of Stands	Method of Drive
1000	500	6600	25	36″	100″	2-High Sc. Br.	1	Geared
4500	370	6600	25	42″–52″	120″	4-High Spreader	1	Geared
						Slab Squeezer	1	
600	140–455	700	DC			Vert. Edger	1	Geared
7000	40–80	700	DC	36″–54″	100″	4-High Rev.	1	Direct
5000	125–250	600	DC	27″–54″	100″	4-High	1	Geared
5000	125–250	600	DC	27″–54″	100″	4-High	1	Geared
5000	125–250	600	DC	27″–54″	100″	4-High	1	Geared
5000	125–250	600	DC	27″–54″	100″	4-High	1	Geared

MOTOR GENERATOR DATA
Reversing Stand and Vert. Edger

	KVA	KW	Voltage	Speed	Freq.	PF
AC Motors	6000		6600	375	25	
DC Generators		2–3000	700	375	DC (with 195,000 HP Sec. Fly wheel)	

CARNEGIE-ILLINOIS STEEL CORPORATION, McDONALD, OHIO

HOT STRIP MILL
Estimated Annual Capacity—360,000 Tons

Motor HP	Speed	Voltage	Current	ROLL DATA Dia.	ROLL DATA Length	Type	No. of Stands	Method of Drive
500	500	6600	25	26″	42″	2-High Sc. Br.	1	Geared
700	500	230	DC			Slab Reducer	1	Direct
2500	500	6600	25	32″	42″	2-High	1	Geared
200	200–400	230	DC			Vert. Edger	1	Geared
2500	500	6600	25	32″	42″	2-High	1	Geared
2500	500	6600	25	32″	42″	2-High	1	Geared
200	200–400	230	DC			Vert. Edger	1	Geared
2500	500	6600	25	21″–45″	43″	4-High	1	Geared
500	250–750	230	DC			2-High Sc. Br.	1	Geared
3000	200–400	600	DC	21″–45″	43″	4-High	1	Geared
3500	200–400	600	DC	21″–45″	43″	4-High	1	Geared
3500	200–400	600	DC	21″–45″	43″	4-High	1	Geared
3500	135–270	600	DC	21″–45″	43″	4-High	1	Direct
3000	172–240	600	DC	21″–45″	43″	4-High	1	Direct
2500	185–370	600	DC	21″–45″	43″	4-High	1	Direct

MOTOR GENERATOR DATA

	KVA	KW	Voltage	Speed	Freq.	PF
AC Motors	5600		6600	500	25	
DC Generators		2–2000	600	500	DC	

GREAT LAKES STEEL CORPORATION, ECORSE, MICHIGAN

HOT STRIP MILL
Estimated Annual Capacity—600,000 Tons

Motor HP	Speed	Voltage	Current	ROLL DATA Dia.	ROLL DATA Length	Type	No. of Stands	Method of Drive
1000	300	6600	25			Sc. Br.	1	Geared
3000	150	6600	60	36″–49″	96″	Spreader	1	Geared
150	450–900	600	DC			Edger	1	Geared
3000	514	6600	60	25″–49″	79″	4-High	1	Geared
150	450–900	600	DC			Edger		Geared
3000	514	6600	60	25″–49″	79″	4-High	1	Geared

Motor HP	Speed	Voltage	Current	ROLL DATA Dia.	Length	Type	No. of Stands	Method of Drive
150	450–900	600	DC			Edger		Geared
3000	514	6600	60	25″–49″	79″	4-High	1	Geared
500	150–600	600	DC			Sc. Br.	1	Geared
4500	150–600	600	DC	25″–49″	79″	4-High	1	Geared
4500	125–250	600	DC	25″–49″	79″	4-High	1	Geared
4500	125–250	600	DC	25″–49″	79″	4-High	1	Geared
4500	125–250	600	DC	25″–49″	79″	4-High	1	Geared
4500	125–250	600	DC	25″–49″	79″	4-High	1	Geared
3000	175–350	600	DC	25″–49″	79″	4-High	1	Geared

MOTOR GENERATOR DATA
3 Motor Generator Sets

	KVA	KW	Voltage	Speed	Freq.	PF
AC Motors	8500		6600	360	60	
DC Generators		2–3000	600	360	DC	

COLD STRIP, SHEET AND TIN MILLS

AMERICAN ROLLING MILL COMPANY, MIDDLETOWN, OHIO

TANDEM COLD STRIP MILL
Estimated Annual Capacity—250,000 Tons

Motor HP	Speed	Voltage	Current	ROLL DATA Dia.	Length	Type	No. Stands	Method of of Drive
1500	300–600	600	DC	19″–49″	80″	4-High	1	Geared
1500	300–600	600	DC	19″–49″	80″	4-High	1	Geared
1500	300–600	600	DC	19″–49″	80″	4-High	1	Geared
600	300–1050	600	DC			Reel		Geared

MOTOR GENERATOR DATA

	KVA	KW	Voltage	Speed	Freq.	PF
AC Motors	5500		6600	500	60	.8
DC Generators		2000	600	500	DC	

AMERICAN SHEET & TIN PLATE COMPANY, GARY, INDIANA

COLD STRIP MILLS
Estimated Annual Capacity—250,000 Tons

REVERSING COLD MILL

Motor HP	Speed	Voltage	Current	ROLL DATA Dia.	Length	Type	No. of Stands	Method of Drive
1500	150–525	600	DC			Reel		Geared
4000	150–300	600	DC	20½–56″	60″	4-High	1	Geared
1500	150–525	600	DC			Reel		Geared

TANDEM COLD MILL

Motor HP	Speed	Voltage	Current	Dia.	Length	Type	No. of Stands	Method of Drive
500	400–800	600	DC	20″–53″	42″	4-High	1	Geared
1250	300–600	600	DC	20″–53″	42″	4-High	1	Geared
1250	300–600	600	DC	20″–53″	42″	4-High	1	Geared
1250	300–600	600	DC	20″–53″	42″	4-High	1	Geared
1250	300–600	600	DC	20″–53″	42″	4-High	1	Geared
250	300–1200	600	DC			Reel		Geared

MOTOR GENERATOR DATA

	KVA	KW	Voltage	Speed	Freq.	PF
AC Motors	2200		2300	750	60	
DC Generators		1400	600	750	DC	

TANDEM COLD MILL

Motor HP	Speed	Voltage	Current	Dia.	Length	Type	No. of Stands	Method of Drive
2500	225–450	600	DC	20½″–56″	84″	4-High	1	Geared
2500	225–450	600	DC	20½″–56″	84″	4-High	1	Geared
350	200–600	600	DC			Reel		Geared

BETHLEHEM STEEL COMPANY, LACKAWANNA, N. Y.

COLD STRIP MILLS
Estimated Annual Capacity—250,000 Tons

TANDEM COLD STRIP MILL

Motor HP	Speed	Voltage	Current	ROLL DATA Dia.	Length	Type	No. of Stands	Method of Drive
1250	300–600	600	DC	20″–49″	76″	4-High	1	Geared
1250	300–600	600	DC	20″–49″	76″	4-High	1	Geared
1250	300–600	600	DC	20″–49″	76″	4-High	1	Geared
150–225	225–900	600	DC			Reel		Geared

TANDEM COLD STRIP MILL

Motor HP	Speed	Voltage	Current	Dia.	Length	Type	No. of Stands	Method of Drive
1250	300–600	600	DC	20″–49″	54″	4-High	1	Geared
1250	300–600	600	DC	20″–49″	54″	4-High	1	Geared
1250	300–600	600	DC	20″–49″	54″	4-High	1	Geared
150–225	225–900	600	DC			Reel		Geared

MOTOR GENERATOR DATA

	KVA	KW	Voltage	Speed	Freq.	PF
AC Motors	1–6600		6600	500	25	1.0
DC Generators		2–3000	600	500	DC	

COLD STRIP MILL

1250	300–600	600	DC	20″–49″	76″	4-High	1	Geared
150–225	225–900	600	DC			Reel		Geared

COLD SHEET MILL

1250	300–600	600	DC	20″–49″	76″	4-High	1	Geared

MOTOR GENERATOR DATA

	KVA	KW	Voltage	Speed	Freq.	PF
AC Motors	3750		6600	500	25	
DC Generators		2–1250	600	500	DC	

COLD SHEET MILL

1250	300–600	600	DC		90″	4-High	1	Geared

SKIN PASS MILL

250	500–1000	250	DC		54″	4-High	1	Geared
60–125	225–900	250	DC			Reel		Geared

MOTOR GENERATOR DATA

	KVA	KW	Voltage	Speed	Freq.	PF
AC Motors	2000		6600	750	25	
DC Generators		2–500	300	750	DC	
(Series connected for 90″ cold sheet mill)						
DC Generators		1–300	250	750	DC	

BETHLEHEM STEEL COMPANY, SPARROWS POINT, MD.

COLD STRIP MILLS
Estimated Annual Capacity—108,000 Gr. Tons

TANDEM COLD MILL

Motor HP	Speed	Voltage	Current	Dia.	Length	Type	No. of Stands	Method of Drive
800	600–800	600	DC	18″–49″	42″	4-High	1	Direct
800	600–800	600	DC	18″–49″	42″	4-High	1	Direct
800	600–800	600	DC	18″–49″	42″	4-High	1	Direct
800	600–800	600	DC	18″–49″	42″	4-High	1	Direct
800	600–800	600	DC	18″–49″	42″	4-High	1	Direct
150–225	225–900	600	DC			Reel		Geared

MOTOR GENERATOR DATA

	KVA	KW	Voltage	Speed	Freq.	PF
AC Motors	4800		6600	750	25	.8
DC Generators		3500	600	750	DC	

SKIN PASS MILL

Motor HP	Speed	Voltage	Current	Dia.	Length	Type	No. of Stands	Method of Drive
500	900	600	DC	18″–49″	42″	4-High	1	Direct
100–125	300–1200	600	DC		42″	Reel		Geared

SKIN PASS MILL

500	900	600	DC	18″–49″	42″	4-High	1	Direct
100–125	300–1200	600	DC		42″	Reel		Geared

MOTOR GENERATOR DATA

	KVA	KW	Voltage	Speed	Freq.	PF
AC Motors	1425		6600	750	25	.8
DC Generators		2–500	600	750	DC	

CROWN CORK AND SEAL COMPANY, BALTIMORE, MD.

COLD STRIP MILLS
Estimated Annual Capacity—75,000 Gr. Tons

TANDEM COLD MILL

Motor HP	Speed	Voltage	Current	ROLL DATA Dia.	Length	Type	No. of Stands	Method of Drive
600	500–800	250	DC	16″–40″	30″	4-High	1	Geared
600	500–800	250	DC	16″–40″	30″	4-High	1	Geared
600	500–800	250	DC	16″–40″	30″	4-High	1	Geared
600	500–800	250	DC	16″–40″	30″	4-High	1	Geared
50	300–1200	250	DC			Reel		Geared

DETROIT STEEL CORPORATION, DETROIT, MICH.

REVERSING COLD STRIP MILL
Estimated Annual Capacity—20,000 Tons

Motor HP	Speed	Voltage	Current	ROLL DATA Dia.	Length	Type	No. of Stands	Method of Drive
150	300–1100	250	DC	Reel				Geared
500	500–800	250	DC	10½″–26″	24″	4-High	1	Geared
150	300–1100	250	DC	Reel				Geared

MOTOR GENERATOR SET

	KW	Voltage	Speed
DC Generators	1–1700	230	900

GREAT LAKES STEEL CORPORATION, ECORSE, MICH.

COLD STRIP MILLS
Estimated Annual Capacity—250,000 Tons

TANDEM COLD STRIP MILL

Motor HP	Speed	Voltage	Current	ROLL DATA Dia.	Length	Type	No. of Stands	Method of Drive
1250	300–600	600	DC			4-High	1	Geared
1250	300–600	600	DC			4-High	1	Geared
1250	300–600	600	DC			4-High	1	Geared
150–225	225–900	600	DC			Reel		Geared

TANDEM COLD STRIP MILL

1250	300–600	600	DC	4-High	1	Geared
1250	300–600	600	DC	4-High	1	Geared
1250	300–600	600	DC	4-High	1	Geared
150–225	225–900	600	DC	Reel		Geared

MOTOR GENERATOR DATA

	KVA	KW	Voltage	Speed	Freq.	PF
AC Motors	8500		6600	360	60	
DC Generators		2–3000	600	360	DC	

COLD STRIP MILL

1250	300–600	600	DC	4-High	1	Geared
150–225	225–900	600	DC	Reel		Geared

COLD SHEET MILL

1250	300–600	600	DC	4-High	1	Geared

SKIN PASS MILL

250	500–1000	250	DC	4-High	1	Geared
60–125	225–900	250	DC	Reel		Geared

MOTOR GENERATOR DATA

	KVA	KW	Voltage	Speed	Freq.	PF
AC Motors	4000		6600	720	60	
DC Generators	2–1250 KW at 600 V.—1-300 KW at 250 V.					

JONES & LAUGHLIN STEEL CORPORATION, ALIQUIPPA, PA.

COLD STRIP MILL
Estimated Annual Capacity—15,000 Tons

SKIN PASS MILL

Motor HP	Speed	Voltage	Current	ROLL DATA Dia.	Length	Type	No. of Stands	Method of Drive
500	450–900	250	DC	20″–49″	42″	4-High	1	Geared
150	575–1150	250	DC			Reel		Geared

MOTOR GENERATOR DATA

	KVA	KW	Voltage	Speed	Freq.	PF
AC Motors	850		6600	750	25	.8
DC Generators		1–500	250	750	DC	
		1–125	250	750	DC	

REPUBLIC STEEL CORPORATION, WARREN, OHIO

COLD STRIP MILL
Estimated Annual Capacity—25,000 Tons

Motor HP	Speed	Voltage	Current	ROLL DATA Dia.	Length	Type	No. of Stands	Method of Drive
300	300–1200	250	DC	Reel				Geared
1200	400–800	250	DC	16″–49″	42″	4-High	1	Geared
300	300–1200	250	DC	Reel				Geared

WALLINGFORD STEEL COMPANY, WALLINGFORD, CONN.

REVERSING COLD STRIP MILL
Estimated Annual Capacity—20,000 Tons

Motor HP	Speed	Voltage	Current	ROLL DATA Dia.	Length	Type	No. of Stands	Method of Drive
150	300–1200	250	DC	Reel				Geared
800	500–800	250	DC	12″–33″	39″	4-High	1	Geared
150	300–1200	250	DC	Reel				Geared

MOTOR GENERATOR DATA

	KVA	KW	Voltage	Speed	Freq.	PF
AC Motors	880		550	900	60	
DC Generarors		1–750	250	900	DC	
		1–60	250	900	DC	

WEST LEECHBURG STEEL COMPANY, WEST LEECHBURG, PA.

COLD STRIP MILL
Estimated Annual Capacity—15,000 Tons

Motor HP	Speed	Voltage	Current	ROLL DATA Dia.	Length	Type	No. of Stands	Method of Drive
800	500–800	250	DC	12″–33″	30″	4-High	1	Geared
300	300–1000	250	DC			Reel		Geared

MOTOR GENERATOR DATA

	KVA	KW	Voltage	Speed	Freq.	PF
AC Motors	1100		2200	900	60	
DC Generators		750	250	900	DC	

JONES & LAUGHLIN STEEL CORPORATION, PITTSBURGH, PA.

BLOOMING MILL
Estimated Annual Capacity—700,000 Tons

Motor HP	Speed	Voltage	Current	ROLL DATA Dia.	Length	Type	No. of Stands	Method of Drive
7000	50–120	750	DC	44″	90″	2-High	1	Direct

MOTOR GENERATOR DATA

	KVA	KW	Voltage	Speed	Freq.	PF
AC Motors	5000		6600	375	25	
DC Generators		2–3000	750	375	DC	

1—163,000 H.P. Sec.—Flywheel.

ELECTRIC MOTORS OVER 300 HORSEPOWER

APPLIED TO MAIN ROLL DRIVES IN THE IRON AND STEEL AND ALLIED INDUSTRIES DURING THE YEAR 1935

No.	H.P.	Speed	Voltage	Freq.	Type of Mill	Method of Drive	Purchaser	Plant Location	Mfgd. By
1	300	250/750	250	DC	Rod	Direct	Northwestern Barb Wire Co.	Sterling, Ill.	W.
2	300	250/750	250	DC	Rod	Direct	Northwestern Barb Wire Co.	Sterling, Ill.	W.
3	300	300/1200	250	DC	Cold Strip	Geared	Republic Steel Corp.	Warren, Ohio	W.
4	300	300/1200	250	DC	Cold Strip	Geared	Republic Steel Corp.	Warren, Ohio	W.
5	300	350/750	600	DC	Rod	Direct	Laclede Steel Co.	St. Louis, Mo.	W.
6	300	450/900	250	DC	Cold Strip Reel	Geared	Crown Cork and Seal Company	Baltimore, Md.	W.
7	300	600/1200	230	DC	Wire	Geared	Scoville Mfg. Company	Bridgeport, Conn.	W.
8	350	200/600	600	DC	84″ Tandem Strip Reel	Geared	American Sheet & Tin Plate Co.	Gary, Indiana	G.E.
9	350	350/900	250	DC	Cold Strip Reel	Geared	Weirton Steel Co.	Weirton, W. Va.	W.
10	350	400/700	600	DC	38″ Hot Strip Edger	Geared	Carnegie-Illinois Steel Corp.	Gary, Indiana	G.E.
11	350	400/800	230	DC	84″ Hot Strip Edger	Geared	American Sheet & Tin Plate Co.	Gary, Ind.	G.E.
12	350	400/800	230	DC	84″ Hot Strip Edger	Geared	American Sheet & Tin Plate Co.	Gary, Ind.	G.E.
13	350	400/800	230	DC	84″ Hot Strip Edger	Geared	American Sheet & Tin Plate Co.	Gary, Ind.	G.E.
14	400	250/1000	230	DC	60″ Tempering Pass Cold Strip	Geared	American Sheet & Tin Plate Co.	Gary, Ind.	G.E.
15	400	250/1000	230	DC	84″ Tempering Pass Cold Strip	Geared	American Sheet & Tin Plate Co.	Gary, Ind.	G.E.
16	400	400/1200	230	DC	60″ Tempering Pass Cold Sheet	Geared	American Sheet & Tin Plate Co.	Gary, Ind.	G.E.
17	400	600/1200	600	DC	Cold Strip	Geared	Weirton Steel Co.	Weirton, W. Va.	W.
18	500	150/600	600	DC	79″ Hot Strip Scale Breaker	Geared	Bethlehem Steel Co.	Lackawanna, N. Y.	G.E.
19	500	150/600	600	DC	79″ Hot Strip Scale Breaker	Geared	Great Lakes Steel Corp.	Ecorse, Mich.	G.E.
20	500	250/750	600	DC	Hot Strip	Geared	Carnegie-Illinois Steel Corp.	McDonald, Ohio	W.
21	500	300/1050	600	DC	66″ Tandem Cold Strip Reel	Geared	Zaporozhstal Steel Works	U. S. S. R.	G.E.
22	500	400/800	600	DC	Cold Strip Reel	Geared	American Sheet & Tin Plate Co.	Gary, Ind.	W.
23	500	450/900	250	DC	42″ Tempering Pass Cold Strip	Geared	Jones & Laughlin Steel Corp.	Aliquippa, Pa.	G.E.
24	500	500	6600	25	42″ Hot Strip Scale Breaker	Geared	Carnegie-Illinois Steel Corp.	McDonald, Ohio	G.E.
25	500	500/800	250	DC	24″ Rev. Cold Strip	Geared	Detroit Steel Corp.	Detroit, Mich.	G.E.
26	500	900	600	DC	Skin Pass Stands	Direct	Bethlehem Steel Co.	Sparrows Point, Md.	C-W
27	500	900	600	DC	Skin Pass Stands	Direct	Bethlehem Steel Co.	Sparrows Point, Md.	C-W
28	600	140/455	700	DC	100″ Plate Edger	Direct	Carnegie-Illinois Steel Corp.	Homestead, Pa.	W.
29	600	225/787	600	DC	72″ Rev. Cold Strip Reel	Geared	Zaporozhstahl Steel Works	U. S. S. R.	G.E.
30	600	225/787	600	DC	72″ Rev. Cold Strip Reel	Geared	Zaporozhstahl Steel Works	U. S. S. R.	G.E.
31	600	300/1050	600	DC	Cold Strip	Geared	American Rolling Mill Co.	Middletown, Ohio	W.
32	600	500/890	250	DC	Cold	Geared	Crown Cork & Seal Co.	Baltimore, Md.	W.
33	600	500/800	250	DC	Cold Strip	Geared	Crown Cork & Seal Co.	Baltimore, Md.	W.
34	600	500/800	250	DC	Cold Strip	Geared	Crown Cork & Seal Co.	Baltimore, Md.	W.
35	600	500/800	250	DC	Cold Strip	Geared	Crown Cork & Seal Co.	Baltimore, Md.	W.
36	600	500/800	250	DC	Cold Strip	Geared	Crown Cork & Seal Co.	Baltimore, Md.	W.
37	700	480/705	2200	60	Rod	Geared	Keystone Steel & Wire Co.	Peoria, Ill.	W.
38	700	500	230	DC	Slab Reducer	Direct	Carnegie-Illinois Steel Corp.	McDonald, Ohio	C-W
39	800	150/450	600	DC	84″ Hot Strip	Geared	American Sheet & Tin Plate Co.	Gary, Ind.	A-C
40	800	500/800	250	DC	28″ Rev. Cold Strip	Geared	Wallingford Steel Co.	Wallingford, Conn.	G.E.
41	800	500/800	250	DC	Cold Strip	Geared	West Leechburg Steel Co.	W. Leechburg, Pa.	W.
42	800	600/800	600	DC	Cold Tandem	Direct	Bethlehem Steel Co.	Sparrows Point, Md.	C-W
43	800	600/800	600	DC	Cold Tandem	Direct	Bethlehem Steel Co.	Sparrows Point, Md.	C-W
44	800	600/800	600	DC	Cold Tandem	Direct	Bethlehem Steel Co.	Sparrows Point, Md.	C-W
45	800	600/800	600	DC	Cold Tandem	Direct	Bethlehem Steel Co.	Sparrows Point, Md.	C-W
46	800	600/800	600	DC	Cold Tandem	Direct	Bethlehem Steel Co.	Sparrows Point, Md.	C-W
47	1000	300	6600	60	79″ Hot Strip Scale Breaker	Geared	Great Lakes Steel Corp.	Ecorse, Mich.	G.E.
48	1000	375	6600	25	79″ Hot Strip	Geared	Bethlehem Steel Co.	Lackawanna, N. Y.	W.
49	1000	400/800	600	DC	Cold Strip	Geared	Weirton Steel Co.	Weirton, W. Va.	W.
50	1000	400/800	600	DC	Cold Strip	Geared	Weirton Steel Co.	Weirton, W. Va.	W.
51	1200	400/800	250	DC	Cold Strip	Geared	Republic Steel Corp.	Warren, Ohio	W.
52	1250	200/600	600	DC	Cold Strip	Geared	American Sheet & Tin Plate Co.	Gary, Ind.	W.
53	1250	300/600	600	DC	Cold Strip	Geared	American Sheet & Tin Plate Co.	Gary, Ind.	W.
54	1250	300/600	600	DC	Cold Strip	Geared	American Sheet & Tin Plate Co.	Gary, Ind.	W.
55	1250	300/600	600	DC	Cold Strip	Geared	American Sheet & Tin Plate Co.	Gary, Ind.	W.
56	1250	300/600	600	DC	Cold Strip	Geared	Bethlehem Steel Co.	Lackawanna, N. Y.	W.
57	1250	300/600	600	DC	Cold Strip	Geared	Bethlehem Steel Co.	Lackawanna, N. Y.	W.
58	1250	300/600	600	DC	Cold Strip	Geared	Bethlehem Steel Co.	Lackawanna, N. Y.	W.
59	1250	300/600	600	DC	Cold Strip	Geared	Bethlehem Steel Co.	Lackawanna, N. Y.	W.
60	1250	300/600	600	DC	Cold Strip	Geared	Bethlehem Steel Co.	Lackawanna, N. Y.	W.
61	1250	300/600	600	DC	Cold Strip	Geared	Bethlehem Steel Co.	Lackawanna, N. Y.	W.

No.	H.P.	Speed	Voltage	Freq.	Type of Mill	Method of Drive	Purchaser	Plant Location	Mfgd By
62	1250	300/600	600	DC	Cold Strip	Geared	Bethlehem Steel Co.	Lackawanna, N. Y.	W.
63	1250	300/600	600	DC	Cold Strip	Geared	Bethlehem Steel Co.	Lackawanna, N. Y.	W.
64	1250	300/600	600	DC	Cold Strip	Geared	Bethlehem Steel Co.	Lackawanna, N. Y.	W.
65	1250	300/600	600	DC	Cold Strip	Geared	Great Lakes Steel Corp.	Ecorse, Mich.	W.
66	1250	300/600	600	DC	Cold Strip	Geared	Great Lakes Steel Corp.	Ecorse, Mich.	W.
67	1250	300/600	600	DC	Cold Strip	Geared	Great Lakes Steel Corp.	Ecorse, Mich.	W.
68	1250	300/600	600	DC	Cold Strip	Geared	Great Lakes Steel Corp.	Ecorse, Mich.	W.
69	1250	300/600	600	DC	Cold Strip	Geared	Great Lakes Steel Corp.	Ecorse, Mich.	W.
70	1250	300/600	600	DC	Cold Strip	Geared	Great Lakes Steel Corp.	Ecorse, Mich.	W.
71	1250	300/600	600	DC	Cold Strip	Geared	Great Lakes Steel Corp.	Ecorse, Mich.	W.
72	1250	300/600	600	DC	Cold Strip	Geared	Great Lakes Steel Corp.	Ecorse, Mich.	W.
73	1250	450/700	600	DC	Rod	Geared	Laclede Steel Co.	St. Louis, Mo.	W.
74	1250	514	6600	60	84″ Hot Strip Scale Breaker	Geared	American Sheet & Tin Plate Co.	Gary, Ind.	G.E.
75	1250	900	2200	60	Rod	Geared	Northwestern Barb Wire Co.	Sterling, Ill.	W.
76	1500	150/525	600	DC	Cold Strip	Geared	American Sheet & Tin Plate Co.	Gary, Ind.	W.
77	1500	150/525	600	DC	Cold Strip	Geared	American Sheet & Tin Plate Co.	Gary, Ind.	W.
78	1500	300/600	600	DC	Cold Strip	Geared	American Rolling Mill Co.	Middletown, Ohio	W.
79	1500	300/600	600	DC	Cold Strip	Geared	American Rolling Mill Co.	Middletown, Ohio	W.
80	1500	300/600	600	DC	Cold Strip	Geared	American Rolling Mill Co.	Middletown, Ohio	W.
81	1500	300/600	600	DC	Cold Strip	Geared	Weirton Steel Co.	Weirton, W. Va.	W.
82	2000	277	2200	60	Rod	Direct	Northwestern Barb Wire Co.	Sterling, Ill.	W.
83	2500	175/350	600	DC	79″ Hot Strip Finisher	Geared	Bethlehem Steel Co.	Lackawanna, N. Y.	G.E.
84	2500	185/370	600	DC	Hot Strip	Direct	Carnegie-Illinois Steel Corp.	McDonald, Ohio	W.
85	2500	225/450	600	DC	84″ Tandem Cold Strip	Geared	American Sheet & Tin Plate Co.	Gary, Ind.	G.E.
86	2500	225/450	600	DC	84″ Tandem Cold Strip	Geared	American Sheet & Tin Plate Co.	Gary, Ind.	G.E.
87	2500	500	6600	25	42″ Hot Strip Rougher	Geared	Carnegie-Illinois Steel Corp.	McDonald, Ohio	G.E.
88	2500	500	6600	25	42″ Hot Strip Rougher	Geared	Carnegie-Illinois Steel Corp.	McDonald, Ohio	G.E.
89	2500	500	6600	25	42″ Hot Strip Rougher	Geared	Carnegie-Illinois Steel Corp.	McDonald, Ohio	G.E.
90	2500	500	6600	25	42″ Hot Strip Rougher	Geared	Carnegie-Illinois Steel Corp.	McDonald, Ohio	G.E.
91	3000	100/255	600	DC	Hot Strip	Direct	American Sheet & Tin Plate Co.	Gary, Ind.	A-C
92	3000	150	6600	25	Hot Strip	Geared	Bethlehem Steel Co.	Lackawanna, N. Y.	W.
93	3000	150	6600	60	79″ Hot Strip Spreader	Geared	Great Lakes Steel Corp.	Ecorse, Mich.	G.E.
94	3000	170/340	600	DC	Hot Strip	Direct	Carnegie-Illinois Steel Corp.	McDonald, Ohio	W.
95	3000	175/350	600	DC	79″ Hot Strip Finisher	Geared	Great Lakes Steel Corp.	Ecorse, Mich.	G.E.
96	3000	200/400	600	DC	Hot Strip	Geared	Carnegie-Illinois Steel Corp.	McDonald, Ohio	W.
97	3000	500	6600	25	Hot Strip	Geared	Bethlehem Steel Co.	Lackawanna, N. Y.	W.
98	3000	500	6600	25	Hot Strip	Geared	Bethlehem Steel Co.	Lackawanna, N. Y.	W.
99	3000	500	6600	25	Hot Strip	Geared	Bethlehem Steel Co.	Lackawanna, N. Y.	W.
100	3000	514	6600	60	79″ Hot Strip Rougher	Geared	Great Lakes Steel Corp.	Ecorse, Mich.	G.E.
101	3000	514	6600	60	79″ Hot Strip Rougher	Geared	Great Lakes Steel Corp.	Ecorse, Mich.	G.E.
102	3000	514	6600	60	79″ Hot Strip Rougher	Geared	Great Lakes Steel Corp.	Ecorse, Mich.	G.E.
103	3500	135/275	600	DC	Hot Strip	Direct	Carnegie-Illinois Steel Corp.	McDonald, Ohio	W.
104	3500	175/350	600	DC	79″ Hot Strip Finisher	Geared	Bethlehem Steel Co.	Lackawanna, N. Y.	G.E.
105	3500	175/350	600	DC	79″ Hot Strip Finisher	Geared	Bethlehem Steel Co.	Lackawanna, N. Y.	G.E.
106	3500	175/350	600	DC	79″ Hot Strip Finisher	Geared	Bethlehem Steel Co.	Lackawanna, N. Y.	G.E.
107	3500	200/400	600	DC	Hot Strip	Geared	Carnegie-Illinois Steel Corp.	McDonald, Ohio	W.
108	3500	200/400	600	DC	Hot Strip	Geared	Carnegie-Illinois Steel Corp.	McDonald, Ohio	W.
109	3500	360	6600	60	84″ Hot Strip Spreader	Geared	American Sheet & Tin Plate Co.	Gary, Ind.	G.E.
110	3500	514	6600	60	84″ Hot Strip Rougher	Geared	American Sheet & Tin Plate Co.	Gary, Ind.	G.E.
111	3500	514	6600	60	84″ Hot Strip Rougher	Geared	American Sheet & Tin Plate Co.	Gary, Ind.	G.E.
112	3500	514	6600	60	84″ Hot Strip Rougher	Geared	American Sheet & Tin Plate Co.	Gary, Ind.	G.E.
113	4000	112½/160	600	DC	Plate	Direct	Republic Steel Corp.	Youngstown, Ohio	W.
114	4000	150/300	600	DC	Cold Strip	Geared	American Sheet & Tin Plate Co.	Gary, Ind.	W.
115	4000	400	6600	60	Hot Strip	Geared	American Rolling Mill Co.	Middletown, Ohio	W.
116	4500	85/190	600	DC	84″ Hot Strip Mill	Direct	American Sheet & Tin Plate Co.	Gary, Ind.	A-C
117	4500	100/230	600	DC	84″ Hot Strip Mill	Direct	American Sheet & Tin Plate Co.	Gary, Ind.	A-C
118	4500	125/250	600	DC	79″ Hot Strip Finisher	Geared	Great Lakes Steel Corporation	Ecorse, Mich.	G-E
119	4500	125/250	600	DC	79″ Hot Strip Finisher	Direct	Great Lakes Steel Corporation	Ecorse, Mich.	G-E
120	4500	125/250	600	DC	79″ Hot Strip Finisher	Geared	Great Lakes Steel Corporation	Ecorse, Mich.	G-E
121	4500	125/250	600	DC	79″ Hot Strip Finisher	Geared	Great Lakes Steel Corporation	Ecorse, Mich.	G-E
122	4500	125/250	600	DC	79″ Hot Strip Finisher	Geared	Great Lakes Steel Corporation	Ecorse, Mich.	G-E
123	4500	125/250	600	DC	79″ Hot Strip Finisher	Geared	Bethlehem Steel Company	Lackawanna, N. Y.	G-E
124	4500	125/250	600	DC	79″ Hot Strip Finisher	Geared	Bethlehem Steel Company	Lackawanna, N. Y.	G-E
125	4500	125/282	600	DC	Hot Strip Millf	Geared	American Sheet & Tin Plate Co.	Gary, Ind.	A-C
126	4500	125/282	600	DC	Hot Strip Mill	Geared	American Sheet & Tin Plate Co.	Gary, Ind.	A-C
127	4500	125/282	600	DC	Hot Strip Mill	Geared	American Sheet & Tin Plate Co.	Gary, Ind.	A-C
128	4500	370	6600	25	100″ Plate Mill	Geared	Carnegie-Illinois Steel Corp.	Homestead, Pa.	W
129	7000	40/80	700	DC	100″ Plate Mill	Direct	Carnegie-Illinois Steel Corp.	Homestead, Pa.	W
130	7000	50/120	750	DC	44″ Rev. Blooming	Direct	Jones & Laughlin Steel Corp.	Pittsburgh, Pa.	G-E

ELECTRICALLY OPERATED CRANE STATISTICS---1935

ELECTRIC OVERHEAD TRAVELING CRANES, CHARGERS, HOISTS PURCHASED BY IRON AND STEEL INDUSTRY

TABLE NO. 1

TREND OF BEARING CONSTRUCTION

Number of Cranes	Crane Tonnage	Completely Equipped with Anti-Friction Bearings	Partially Equipped	Sleeve Bronze Bearings Etc.
2	1	2	..	..
2	2	1	1	..
3	3	2	1	..
7	5	..	7	..
2	7½	2	..	..
19	10	12	3	4
39	15	34	4	1
8	20	3	3	2
10	25	10	..	..
8	30	6	1	1
1	40	..	1	..
5	50	3	1	1
2	60	1	1	..
4	75	4	..	..
1	80	1	..	..
1	125	..	..	1
1	200	1	..	..
2	350	2	..	..
117	—	84	23	10

TROLLEYS PURCHASED

Number	Tonnage	Completely Equipped with Anti-Friction Bearings	Partially Equipped	Sleeve Bronze Bearings Etc.
1	5	1	..	..
2	10	1	..	1
1	15	1	..	..
1	40	1	..	..
1	150	..	..	1
1	200	..	..	1
7	—	4	..	3

BRIDGES PURCHASED

Number	Tonnage	Completely Equipped with Anti-Friction Bearings	Partially Equipped	Sleeve Bronze Bearings Etc.
2	7½	..	..	2

TYPE OF GEARING

Cranes equipped with Spur Gears	60
Spur and Worm Gears	37
Spur and Helical Gears	4
Spur and Herringbone Gears	14
Worm Gears	2
Total	117

TABLE NO. 2

TYPE OF CRANES PURCHASED

Standard Cranes	50
Hook Cranes	15
Single Eye Beam—Underhung	2
Double Eye Beam—Overhead	2
Soaking Pit Cranes	6
Comb. Strip and Extractor	1
Gantry	3
Mill Cranes	30
Special 2 Hoist	1
Standard (Special Revolving Hoist)	1
Wharf	2
Open Hearth Charger	1
Special (Floor Controlled)	3
	117

COMPILATION

Total Cranes Purchased		117
Cranes completely equipped with Anti-Friction Bearings	84	
Cranes partially equipped with Anti-Friction Bearings	23	
Cranes equipped with Sleeve, Bronze Bearings, etc.	10	
Total	117	
Trolleys Purchased		7
Trolleys completely equipped with Anti-Friction Bearings	4	
Trolleys equipped with Sleeve, Bronze Bearings, etc.	3	
Total	7	
Bridges Purchased		2
Bridges equipped with Sleeve, Bronze Bearings, etc.	2	
Bridges with Spur Gears	2	
Trolleys with Spur Gears	5	
Trolleys with Worms and Spur Gears	1	
Trolleys with Spur and Herringbone Gears	1	
Total	7	
Motors furnished	476	
Total Tonnage purchased	3900	
Cranes, Trolleys and Bridges Using D C Current	118	
Cranes, Trolleys and Bridges Using A C Current	8	
		126

STATISTICS AND ANAYSIS OF ELECTRIC MOTORS OVER 300 HP.

SOLD FOR MAIN ROLL DRIVE SERVICE IN THE IRON AND STEEL INDUSTRY IN 1935

APPLICATION OF MOTORS TO VARIOUS TYPES OF MILLS

Type of Mill	Number	Total Motors	Total Horsepower
Blooming	1	1	7,000
Plate	2	4	16,100
Hot Strip	6	54	152,150
Cold Strip	13	63	64,050
Rod	3	7	6,100
Wire	1	1	300
	26	130	245,700

ANALYSIS OF MOTORS PURCHASED AND THEIR APPLICATION

Company	Location	Type of Mill	Total Motors	Total Horsepower
American Rolling Mill Co.	Middletown, O.	Hot Strip	1	4,000
American Rolling Mill Co.	Middletown, O.	Cold Strip	4	5,100
American Sheet & Tin Plate Co.	Gary, Ind.	Hot Strip	15	42,600
American Sheet & Tin Plate Co.	Gary, Ind.	Cold Strip	14	19,050
Bethlehem Steel Co.	Lackawanna, N. Y.	Hot Strip	12	35,500
Bethlehem Steel Co.	Lackawanna, N. Y.	Cold Strip	9	11,250
Bethlehem Steel Co.	Sparrows Point, Md.	Cold Strip	7	5,000
Carnegie-Illinois Steel Corp.	Gary, Ind.	Hot Strip	1	350
Carnegie-Illinois Steel Corp.	McDonald, O.	Hot Strip	13	30,700
Carnegie-Illinois Steel Corp.	Munhall, Pa.	Plate	3	12,100
Crown Cork & Seal Co.	Baltimore, Md.	Cold Strip	6	3,300
Detroit Steel Corp.	Detroit, Mich.	Cold Strip	1	500
Great Lakes Steel Corp.	Ecorse, Mich.	Hot Strip	12	39,000
Great Lakes Steel Corp.	Ecorse, Mich.	Cold Strip	8	10,000
Jones & Laughlin Steel Corp.	Aliquippa, Pa.	Cold Strip	1	500
Jones & Laughlin Steel Corp.	Pittsburgh, Pa.	Blooming	1	7,000
Keystone Steel & Wire Co.	Peoria, Ill.	Rod	1	700
Laclede Steel Co.	St. Louis, Mo.	Rod	2	1,550
Northwestern Barb Wire Co.	Sterling, Ill.	Rod	4	3,850
Republic Steel Corp.	Warren, O.	Cold Strip	3	1,800
Republic Steel Corp.	Youngstown, O.	Plate	1	4,000
Scoville Mfg. Co.	Bridgeport, Conn.	Wire	1	300
Wallingford Steel Co.	Wallingford, Conn.	Cold Strip	1	800
Weirton Steel Co.	Weirton, W. Va.	Cold Strip	5	4,250
West Leechburg Steel Co.	W. Leechburg, Pa.	Cold Strip	1	800
Zaporozhstahl	U.S.S.R.	Cold Strip	3	1,700
			130	245,700

TYPES OF MOTORS PURCHASED

	Total Motors	Total Horsepower
Alternating Current Motors	25	64,200
Direct Current Motors	105	181,500
	130	245,700

▲ ▲ ▲ ITEMS OF INTEREST ▲ ▲ ▲

Warren S. Hall to be chief engineer, Chicago District, Carnegie-Illinois Steel Corp. Mr. Hall graduated from Purdue University in the class of 1905, and entered the employ of the United States Steel Corporation in 1911 as a special electrician at the South Works of the Illinois Steel Company and was promoted through the various grades until made electrical engineer in 1917. He was promoted to supt. of shops and Auxiliary Depts in 1929, made supt. of engineering and construction in 1930, acting chief engineer and supt. of auxiliary depts. in 1932, and assistant general supt. at the South Works in February, 1935. Mr. Hall is a past president of the Association of Iron and Steel Electrical Engineers.

▲

Fred E. Kling as announced by the Carnegie-Illinois Steel Corp., has been advanced to Assistant Chief Engineer with headquarters in the Carnegie Building, Pittsburgh, Pa. Mr. Kling is a graduate of the Royal Engineering College of Dortmund, Germany, and entered the employ of the Carnegie Steel Company at Youngstown, Ohio, in October, 1902, as a draftsman and steam engineer, He was made assistant chief engineer, Youngstown Works, in January, 1906, and chief engineer in November, 1912, to October 1, 1930, when he was made chief mechanical engineer of the Carnegie Steel Company with Headquarters in Pittsburgh. At the time of the organization of the Carnegie-Illinois Steel Corporation on October 1, 1935, Mr. Kling was made chief engineer of the Pittsburgh District. Mr. Kling is a member of the American Iron & Steel Institute, and the American Society of Mechanical Engineers.

▲

Louis C. Edgar to be Chief Engineer of the Pittsburgh District, Carnegie-Illinois Steel Corp. Mr. Edgar entered the employ of the Carnegie Steel Company at Edgar Thomson Works, Braddock, Pa., in 1905, as a draftsman. He was appointed assistant chief engineer in 1907, and chief engineer in 1916, and has served in that capacity to date. He is a member of the Engineers Society of Western Pennsylvania, having served as a Director, Vice President, and President of that organization, and has served as a Director and a member of various Committees of the Association of Iron and Steel Electrical Engineers.

▲

L. D. Smith has been elected a vice president of the Union Steel Casting Company, effective January 1, to assist D. V. Sherlock, Vice President and General Manager, in the extension of sales. Mr. Smith is also vice president of the Lewis Foundry and Machine Company, Pittsburgh, Pa.

▲

F. E. Gage, formerly superintendent of the Farrel, Pa., works of the American Steel & Wire Co., has been appointed superintendent of the Consolidated Works in Cleveland, succeeding E. F. Brown, who has been made superintendent of the American Works, Cleveland. Mr. Brown succeeds Charles F. Kempert, long superintendent of the American Works, who has retired under the Steel Corporation's retirement plan.

▲

B. E. Pheneger has been appointed superintendent of the Central Furnaces of the Carnegie-Illinois Steel Corp., Cleveland. The two remaining furnaces of this group, formerly operated by the American Steel & Wire Co., are being repaired and will be placed in operation for the manufacture of merchant iron. Mr. Pheneger was for a long time assistant general superintendent of the Newburgh Steel works,

WARREN S. HALL

FRED E. KLING

LOUIS C. EDGAR

REUBEN D. ABBISS

CHARLES R. MOFFATT

G. REED SCHREINER

Cleveland, and since the operation of that plant was discontinued about two years ago, has been dividing his time between the American Steel & Wire Co. and the Lorain plant of the National Tube Co.

▲

Reuben D. Abbiss has been appointed chief engineer, Edgar Thomson Works at Braddock, Pa., to succeed Louis C. Edgar, promoted to chief engineer of the Pittsburgh District. Mr. Abbiss entered the employ of the Carnegie Steel Company at the Edgar Thomson Works in August, 1910, as an apprentice in the engineering department, and was made a special engineer, assistant to the chief engineer on September 1, 1924, which position he has held to date.

Mr. Abbiss graduated from Pennsylvania State College in the Class of 1910 as a Mechanical Engineer.

▲

Charles R. Moffatt, former director of advertising for the Illinois Steel Company for the past 16 years, has been appointed the advertising manager of the Carnegie-Illinois Steel Corporation with headquarters at Pittsburgh. Mr. Moffatt has spent his entire business career with the Illinois Steel Company.

▲

G. Reed Schreiner has been appointed by the Carnegie-Illinois Steel Corporation as the assistant advertising manager. Mr. Schreiner graduated from the University of Pittsburgh in 1916, and took post graduate work in advertising. He was in the United States Army during the World War in 1917. He entered the employ of the Carnegie Steel Company in January, 1919, as a copywriter in the advertising department, which division he has served in up until his recent appointment.

▲

Thomas J. Hillard has been made the manager of sales, Pittsburgh District, Carnegie-Illinois Steel Corporation. Mr. Hillard graduated from Princeton University in 1917. He entered the United States Army service in the World War in May 1917, and was discharged as Captain of Air Corp in February, 1919. For many years he was associated with the oil industry and was Vice-President of the Standard Steel Spring Company from 1933 to 1935.

▲

J. H. Vohr, formerly superintendent of the continuous hot strip mill of the Youngstown Sheet and Tube Company, has accepted a similar position at the Granite City Steel Company, Granite City, Illinois, which company, at the present time, is in the process of installing a wide strip mill. Mr. Vohr has been associated with various steel companies in his career, namely American Sheet and Tin Plate Company, and the Inland Steel Company, Indiana Harbor, Ind.

▲

James K. Sutherland, recently made general superintendent of the continuous hot strip mill and the blooming and skelp mills of the Youngstown Sheet & Tube Co., started in the steel business at the old Brier Hill Steel plant in Youngstown in 1908. In 1923, Brier Hill was purchased by Sheet & Tube and Sutherland continued at the Brier Hill plant, becoming superintendent of the Brier Hill blooming mill in 1926. In 1927 he was transferred to the Campbell plant of Sheet & Tube as superintendent of the blooming and skelp mill, and continued in that capacity until his recent promotion.

▲

Jonathan Ingersoll, who takes Sutherland's former position as superintendent of the blooming and skelp mills, came with The Youngstown Sheet & Tube Co. in 1915, after his graduation from Case School of Applied Science. After a year in the metallurgical department he went into the blooming mills as a recorder and has been with the blooming and skelp mills ever since.

J. E. N. HUME

W. C. STEVENS

J. H. VOHR

Alfred G. Glossbrenner, who has been made superintendent of The Youngstown Sheet & Tube Co.'s continuous hot strip mill, came to the company in February, 1935, as the mill's assistant superintendent. Glossbrenner, after attending the University of Wisconsin, gained his early experience in the steel industry at the American Sheet & Tin Plate Co. and spent five years with the Illinois Steel Co. at South Chicago before coming to Youngstown.

▲

J. E. N. Hume, assistant manager of the General Electric Company's industrial department, has been appointed manager of the department, succeeding the late W. W. Miller, it was announced recently by E. O. Shreve, vice-president of the company. Mr. Hume had been assistant manager for the previous six years and in that capacity was responsible for general sales direction, policies, prices, consignments, and similar activities of the department.

A native of Virginia, Mr. Hume attended school in and near Washington, D. C., then entered the University of Virginia, and was graduated in 1906 with the degree of electrical engineer. In January, 1907, he entered the G-E student engineering or "test" course and, upon completing it, saw service in the company's switchgear and lighting departments and in its Baltimore office. On April 15, 1912, he entered the industrial department, then known as the power and mining department, and has been engaged there ever since. In 1928 he was made manager of motor sales, and in December, 1929, assistant manager of the department, the position he held at the time of his recent appointment to the managership.

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W. C. Stevens of the Cutler-Hammer Company, and formerly the chief engineer, has been raised to the vice-president in charge of engineering. Mr. Stevens, a graduate of Cornell University, started with the company thirty years ago in the engineering department, later spending eighteen years in the sales department. Since 1934 he has devoted his time to engineering work serving in the capacity of chief engineer.

JONATHAN INGERSOLL

JAMES K. SUTHERLAND

ALFRED G. GLOSSBRENNER

Henry A. Roemer, Chairman of the Board and President of the Sharon Steel Hoop Company, Sharon, Pa. was elected president of the Pittsburgh Steel Company, Pittsburgh, Pa., to succeed Homer D. Williams who resigned.

Mr. Roemer and Mr. J. H. Hillman, Jr. were elected directors of Pittsburgh Steel to succeed Mr. Emil Winter and Mr. Dwight Winter who resigned.

Mr. Roemer has always taken an active part in the activities of the A.I.& S.E.E. He was the host to the Spring Engineering Conference held in Youngstown Ohio in April, 1935 and served on the General Arrangements Committee of the thirty first convention held in Pittsburgh, Pa., September 1935.

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Harry Ross Jones of Canton, O., has announced his retirement from active work in the steel industry, effective Dec. 31, 1935.

Mr. Jones was formerly president of the United Steel Co. and of the United Alloy Steel Corp. of Canton, Ohio, and for the past three years has been engaged in organizing the alloy steel division of the Youngstown Sheet & Tube Co. Mr. Jones is one of the pioneers in the manufacture of alloy steels, now used so extensively in all lines, particularly the automotive industry.

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Wray Dudley, formerly electrical engineer, National Tube Company, Pittsburgh, Pa., has been advanced to head the electrical department of the National Works, McKeesport, to succeed E. L. Upp, who is retiring. This change was effective January 1, 1936. For the past 25 years Mr. Upp has been associated with the National Tube Company at the Lorain, Gary and National Works. Before coming to the Pittsburgh Office of the National Tube Company, Mr. Dudley had been affiliated with the American Rolling Mill Company, Ashland, Ky.

Left to right, Lee N., Walter D., Walter H. and Elliott W. Hodson

Walter D. Hodson, President and General Manager, The Hodson Corporation, Chicago, Ill., announces the following changes in the personnel of the Company: L. N. Hodson, Vice President in charge of research and development, W. H. Hodson, Secretary, Manager of engineering sales, and E. W. Hodson treasurer in charge of processes and production.

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G. S. Crane, Cutler-Hammer, Inc., has been promoted to the position of that of the vice-president in charge of sales. Mr. Crane had formerly been the sales manager. Mr. Crane is a graduate of the University of Michigan and began his career with the Cutler-Hammer Company twenty five years ago in the engineering department. He was later transferred to the sales department, serving for a time as manager of the Cleveland office, and for the past twelve years acting as sales manager with headquarters in Milwaukee.

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William J. MacKenzie, who has been assistant to Mr. Jones for the past three years and formerly vice president of the Interstate Iron & Steel Co., now part of the Republic Steel Corp., succeeds Mr. Jones as head of the alloy division of the Youngs-

G. S. CRANE

WRAY DUDLEY

H. A. ROEMER

town Sheet & Tube Co. Mr. MacKenzie is a metallurgist by training and has spent practically all of his business life in the alloy steel business.

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F. Hughes Moyer has resigned as vice-president of the Mackintosh-Hemphill Company with whom he had been associated since 1926. Vice-President of the company in charge of operations from 1926 to 1928, Mr. Moyer succeeded J. Ramsey Speer as president in 1928. When Colonel J. S. Ervin was elected president of the company in 1932, Mr. Moyer continued in the capacity of vice-president and senior engineer.

A graduate of Cornell University in 1899 he has been associated with the steel industry for many years. Among the producing companies he has served are Carnegie Steel Company, Gary and Clairton Plants, Indiana Steel Company and the Cambria Steel Company. Also he had been associated with the Crucible Steel Company, Midland, Pa., and the United Alloy Steel Corp., Canton, Ohio.

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OBITUARIES

William J. McGurty, Pittsburgh representative for the Bartlett Hayward Company, died at his home on December 19. He was 54 years old. A graduate of Columbia University, Mr. McGurty's first employment was with the Consolidated Gas Company of New York. In 1907 he was transferred to the Astoria Light, Heat and Power Company of Long Island where he served this company as a chemist until 1910. In that year he was transferred to the operating staff of the Central Union Gas Company of New York and remained in their employ until 1914 when he joined the technical staff of the Bartlett Hayward Company.

WILLIAM J. McGURTY

During the World War he was loaned for a time to the United States Government and served in the explosive division of the Ordinance department. For the past seven years he has resided in Pittsburgh and during the late years had been very active in the Blast Furnace and Coke field. An associate member of the Association of Iron and Steel Electrical Engineers for many years, Mr. McGurty's passing is a genuine loss to the profession and is deeply regretted by his friends and associates.

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William W. Miller, manager of the General Electric Company's Industrial Department, died in Schenectady, Dec. 22. He was 55 years old.

Born in Rochester, N. Y., Mr. Miller moved to Schenectady with his parents when he was 5 years old, in 1885, and when he was 12 did his first work for General Electric, being employed as an office boy during summer vacation from school.

Graduating from the Union Classical Institute in 1897, he worked for a year as office boy in what was then the General Electric Power and Mining Department when he obtained a leave of absence to go to the Spanish-American war with the Second New York Infantry. Returning to General Electric in 1899, he was assigned to the Armature and Coil-winding Department and, while working days, studied electrical engineering at night.

In 1900, he entered the student engineering or "test" course in which he remained until 1902 when he spent a short time in drafting work and then joined the Power and Mining Department, which later became the present Industrial Department of the company.

When the Bausch and Lomb Optical Company of Rochester, N. Y., decided in 1908 to change from mechanical to electrical drive and called on General Electric for assistance, Mr. Miller was assigned to the job and directly supervised the change-over. Upon completion of this work in 1910, he joined General Electric's Railway Engineering Department but a year later returned to the Power and Mining Department where he helped to form, and was placed in charge of, its mining section.

On March 15, 1920, he was made an assistant manager of the Industrial Department and in December, 1929, when E. O. Shreve became an assistant vice-president, Mr. Miller was made the Industrial Department's manager, the position he held at the time of his death.

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J. G. Obermier, Vice President in charge of Production and Member of the Board of Directors of The Timken Roller Bearing Company, died of pneumonia in Tucson, Arizona, December 28, 1935. Mr. Obermier was born in Cleveland, November 13, 1868 and early became interested in production problems. After working for a number of years in Cleveland, he came to Canton, Ohio and in 1912 joined the Timken organization as Superintendent of Production. He was in active charge of production through the intensive development period of the company, being personally responsible for many of the plant efficiencies which have played an important part in the growth of the organization. In 1921 Mr. Obermier was elected to the Board of Directors and appointed Vice President in Charge of Production, which position he filled actively until within a few weeks of his death.